Parker Automation

p/n YPM08120-1

Acroloop Motion Controller User's Guide Part 1

Effective: October 7, 2002

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CHANGE NOTICE

Users Guide AMCS P/N PM08120 Version Change:
From: Version 1.18.04, Dated 6/30/2000
To: Version 1.18.06 Update 15, Dated 9/28/2001

The following changes have been incorporated into Users Guide Version 1.18.06 Update 09.

1.	Page 22, Memory Organization	Added new commands CIRCCW, CIRCW, DIP, DIN, DZL, DZU, FFVC, FLT, KVF, KVI, KVP, LOOK, MBUF,PASSWORD, TANG, TARC FSTAT.
2.	Page 33, Command Groups	Added new commands: CIRCCW, CIRCW, DIP, DIN, DZL, DZU, FFVC, FLT, KVF, KVI, KVP, LOOK, MBUF,PASSWORD, TANG, TARC.
3.	Page 38, Command Cross Reference	Added new commands: CIRCCW, CIRCW, DIP, DIN, DZL, DZU, FFVC, FLT, KVF, KVI, KVP, LOOK, MBUF,PASSWORD, TANG, TARC FSTAT.
4.	Page 82, Command Reference –	Added CIRCCW command.
5.	Page 83, Command Reference –	Added CIRCW command.
6.	Page 129, Command Reference –	Added CMT LOCK AMP command.
7.	Page 129, Command Reference –	Added DIN command.
8.	Page 130, Command Reference –	Added DIP command.
9.	Page 133, Command Reference –	Added DZL command.
10.	Page 134, Command Reference –	Added DZU command.
11.	Page147, Command Reference –	Added FFVC command.
12.	Page155, Command Reference –	Added FLT command.
13.	Page 161, Command Reference –	Added FSTAT command.
14.	Page 223, Command Reference –	Added KVF command.
15.	Page 224, Command Reference –	Added KVI command.
16.	Page 225, Command Reference –	Added KVP command.
17.	Page 233, Command Reference –	Added LOOK command.
18.	Page243, Command Reference –	Added MBUF command.
19.	Page 261, Command Reference –	Added PASSWORD command.
20.	Page 320, Command Reference –	Added TANG command.
21.	Page 322, Command Reference –	Added TARC command

CHANGE NOTICE, continued

Users Guide AMCS P/N PM08120 Version Change:
From: Version 1.18.02, Dated 10/21/1999
To: Version 1.18.04, Dated 6/30/2000

The following changes have been incorporated into Users Guide Version 1.18.04:

22. Acroloop Motion Controller User's Guide	Split manual into two (2) sections, Part I and Part II.
23. Page 1, Introduction	Added manual section content information.
24. Page 22, Memory Organization	Added new commands: MAXVEL, NURB, SPLINE, TOV
25. Page 33, Command Groups	Added new commands: MAXVEL, NURB, SPLINE, TOV
26. Page 38, Command Cross Reference	Added new commands: CAM ON TRG, CONFIG CLEAR, GEAR ON TRG, GEAR OFF TRG, MAXVEL, NURB, SPLINE, TOV
27. Page 50, Command Reference – ADC NEG	Corrected differential analog input example.
28. Page 68, Command Reference – CAM	Added CAM ON TRG to cam command combinations.
29. Page 80, Command Reference – CAM ON TRG	Added CAM ON TRG command.
30. Page 102, Command Reference – CONFIG	Added CLEAR command to vaid CONFIG command combinations. Corrected CONFIG usage examples.
31. Page 105, Command Reference – CONFIG CLEAR	Added CONFIG CLEAR command. Command was taken out of manual after version 1.13.03, but was still a valid firmware command.
32. Page 106, Command Reference – CONFIG IO and CONFIG XIO	Added note about using the two commands together. Update Usage Example to show both commands.
33. Page 115, Command Reference – DGAIN	Added DGAIN Smooth parameter reference.
34. Page 136, Command Reference – ELOAD	Added flash reference information.
35. Page 138, Command Reference – ENC RD ABS	Added read Yaskawa absolute encoder command.

CHANGE NOTICE, continued

Users Guide Version 1.18.04 changes, continued:

36.	Page 141, Command Reference – ERASE	Added flash reference information.
37.	Page 142, Command Reference – ESAVE	Added flash reference information.
38.	Page 146, Command Reference – FFACC	Corrected acceleration and FFACC references.
39.	Page 154, Command Reference – FLASH	Added warning about using FLASH SAVE and FLASH IMAGE when data is already present in flash.
40.	Page 167, Command Reference – GEAR	Added GEAR ON TRG and GEAR OFF TRG to valid GEAR command combinations. Included new commands in Figure 3.8, Electronic Gearing Diagram.
41.	Page 178, Command Reference – GEAR ON TRG	Added GEAR ON TRG command.
42.	Page 179, Command Reference – GEAR OFF TRG	Added GEAR OFF TRG command.
43.	Page 198, Command Reference – INTCAP	Correced Valid Interrupt Source Modes for ACR1200. Clarified usage examples.
44.	Page 242, Command Reference – MAXVEL	Added MAXVEL command.
45.	Page 247, Command Reference – MOV	Corrected incremental move command using a forward slash.
46.	Page 248, Command Reference – MSEEK	Included unit information to MSEEK.
47.	Page 253, Command Reference – NURB	Added NURB commands, including NURB MODE, NURB RANK, and NURB END.
48.	Page 264, Command Reference – PERIOD	Changed lower period range to 200microseconds.
49.	Page 307, Command Reference – SPLINE	Added SPLINE commands, including SPLINE MODE and SPLINE END.
50.	Page 330, Command Reference – TOV	Added TOV command.
51.	Page 341, Command Reference – VER	Added diagnostic parameter reference.

CHANGE NOTICE, continued

Users Guide AMCS P/N PM08120 Version Change:
From: Version 1.17.07, Dated 5/21/1998
To: Version 1.18.02, Dated 10/21/1999

The following changes have been incorporated into Users Guide Version 1.18.02:

1.	Cover Page	Changed User's Guide title to reflect general controller name.
2.	Page 1, INTRODUCTION	Added ACR1200, ACR1500, and ACR8010 board information.
3.	Page 5,Chapter 1 Overview	Added ACR1200, ACR1500, and ACR8010 hardware manual information.
4.	Page 9, Chapter 2 Overview	Added ACR1200, ACR1500, ACR8010 board references.
5.	Page 10 ~ 13, Communication Channels	Added ACR1200, ACR1500, ACR8010 board references.
6.	Page 14, System Attachments	Added ACR1200, ACR1500, ACR8010 board references.
7.	Page 18 ~ 25, Memory Organization	Added ACR1200, ACR1500, ACR8010 Memory Organization descriptions.
8.	Page 33, Command Groups	Added CMT object to Global objects group. Added TMOV and SYNC to velocity profile group.
9.	Page 38, Command Cross Reference	Added Command Cross Reference chart to manual.
10.	Page 44, Command Reference, ADC Command	Added ADC command information
11.	Page 46, Command Reference, ADC Command	Added ADC mode command
12.	Page 55, Command Reference, ADC Command	Added ADC max command
13.	Page 48, Command Reference, ADC Command	Added ADC scale command
14.	Page 59, Command Reference, ATTACH AXIS Command	Added CMT object as an additional option for output signal

CHANGE NOTICE, continued

Users Guide Version 1.18.02 changes, continued:

15. Page 65, Command Reference, BRESET Command	Added ACR1200/ACR1500/ACR8010 references.
16. Page 87 ~ 101, Command Reference, CMT Command	Added CMT command
17. Page 102, Command Reference, CONFIG Command	Added ACR1200/ACR1500/ACR8010 references and additional examples.
18. Page 107, Command Reference, CONFIG IO MODE Command	Added ACR1500 command.
19. Page 108, Command Reference, CONFIG IO INPUT Command	Added ACR1500 command.
20. Page 108, Command Reference, CONFIG IO OUT Command	Added ACR1500 command.
21. Page 116 ~ 124, Command Reference, DIAG Command	Added ACR1200/ACR1500/ACR8010 references.
22. Page 125, Command Reference, DIM Command	Added DIM LOGGING(size) command
23. Page 154, Command Reference, FLASH Command	Added ACR1200/ACR1500/ACR8010 references.
24. Page 186 ~ 188, Command Reference, HSINT Command	Added ACR1200/ACR1500/ACR8010 references and new HSINT format
25. Page 198 ~ 208, Command Reference, INTCAP Command	Added ACR1200/ACR1500/ACR8010 references and new INTCAP format
26. Page 248 , Command Reference, MSEEK Command	Added ACR1200/ACR1500/ACR8010 references and new MSEEK format
27. Page 264 , Command Reference, PERIOD Command	Added ACR1200/ACR1500/ACR8010 references and new default value for ACR1500
28. Page 279 , Command Reference, PROM Command	Added ACR1200/ACR1500/ACR8010 references.
29. Page 314 ~318, Command Reference, SYNC Command	Added new SYNC commands

CHANGE NOTICE, continued

Users Guide Version 1.18.02 changes, continued:

30.	Page 326 ~ 329, Command Reference, TMOV Command	Added new TMOV Commands
31.	Page 395, PLC Programming, PLC Operation	For ACR8010, the maximum plc instruction for each plc program is increased from 100 to 200

CHANGE NOTICE, continued

Users Guide AMCS P/N PM08120 Version Change:
From: Version 1.17.05, Dated 12/5/97
To: Version 1.17.07, Dated 5/21/98

The following changes have been incorporated into Users Guide Version 1.17.07 and above:

52. Page 13, System Reference, Multiple Board Communication	Corrected usage example.
53. Page 18, System Reference, Memory Organization	Corrected expanded memory figure.
54. Page 25, System Reference, Memory Organization	Added FLASH IMAGE command reference.
55. Page 65, Command Reference, BRESET Command	Added ACR2000/ACR8000/ACR8010 command information.
56. Page 84, Command Reference, CLEAR Command	Corrected spelling.
57. Page 107, Command Reference, CPU Command	Added period command reference.
58. Page 125, Command Reference, DIM Command	Added minimum stream buffer size information.
59. Page 154, Command Reference, FLASH Command	Added Flash Image command and Flash Bypass Mode information.
60. Page 160, Command Reference, FOV Command	Clarified feedrate override description to include move type – feed move.
61. Page 186, Command Reference, HSINT Command	Clarified mode definition location information.
62. Page 248, Command Reference, MSEEK Command	Clarified mode definition location information. Added recommended clearing of register information.
63. Page 264, Command Reference, PERIOD Command	Added recommended foreground/background timing information.
64. Page 291, Command Reference, ROV Command	Clarified rapid feedrate override description to include move type – rapid move.
65. Page 345, Expression Groups	Corrected spelling error.

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INTRODUCTION

This manual will serve as a reference and programmers guide for the ACR1200, ACR1500, ACR2000, ACR8000,ACR8010 and ACR8020 family of motion controllers.

Please reference the Acroloop Motion Controller User's Guide Part II for additional information.

Acroloop Motion Controller User's Guide Part I (P/N PM08120-1) includes:

Chapter 1. Hardware Installation
Chapter 2. System Reference
Chapter 3. Command Reference
Chapter 4. Expression Reference
Chapter 5. PLC Programming

Acroloop Motion Controller User's Guide Part II (P/N PM08120-2) includes:

Chapter 6. Binary Host Interface
Appendix A. Parameter Reference
Appendix B. Flag Reference
Appendix C. Output Modules Software Configuration Examples

The ACR8020 is a floating point DSP based 16 axis motion controller. This board will work in standalone mode as well as within a PCI bus chassis.

The ACR8010 is a floating point DSP-based 8 axis motion controller. It has onboard hardware to read up to eight with the option of ten incremental encoders. The board can supply precision 16-bit analog for eight servo amplifiers or step/direction open-collector ouputs for eight stepper drives. It is modular in nature and is offered in 2, 4, 6 or 8 axis configurations. This board will work in standalone mode as well as within a PC-AT bus chassis. In the PC-AT bus, the board takes one ISA card slot.

The ACR8000 is a floating point DSP-based 8 axis motion controller. It has onboard hardware to read up to eight incremental encoders. The board can supply precision 16-bit analog for eight servo amplifiers or step/direction open-collector ouputs for eight stepper drives. It is modular in nature and is offered in 2, 4, 6 or 8 axis configurations. This board will work in standalone mode as well as within a PC-AT bus chassis. In the PC-AT bus, the board takes one and one half ISA slots.

The ACR2000 is a floating point DSP-based 4 axis motion controller. It has onboard hardware to read up to four incremental encoders. The board can supply precision 16-bit analog for four servo amplifiers or step/direction open-collector ouputs for four stepper drives. It is modular in nature and is offered in 2 or 4 axis configurations. This board will work in standalone mode as well as within a PC-AT bus chassis. In the PC-AT bus, the board takes a single half-card ISA slot.

Introduction, continued

The ACR1500 is a floating point DSP-based 4 axis motion controller. It has onboard hardware to read up to four incremental encoders. The board can supply precision 16-bit analog for four servo amplifiers or step/direction open-collector ouputs for four stepper drives. It is modular in nature and is offered in 2 or 4 axis configurations. This board is a PC-AT card only. In the PC-AT bus, the board takes a single half-card ISA slot.

The ACR1200 is a floating point DSP-based 2 axis motion controller. It has onboard hardware to read up to three incremental encoders. The board can supply precision 16-bit analog for two servo amplifiers or step/direction open-collector ouputs for two stepper drives. It is modular in nature and is offered in 1 or 2 axis configurations. This board is a standalone card only.

Version 1.18 and above:

Software commutation for brushless motors is available on ACR1200, ACR1500, ACR8010 and ACR2000 Version 1.18 and above, only. Commutation is not available on the ACR8000 Board.

Each commutator uses two 16-bit analog outputs to generate sinusoidal or trapezoidal signals to command “phased sine” input type servo amplifiers. Therefore, the ACR8010 can control a maximum of four (4) axis, if they are all being commutated. The ACR1500 and ACR2000 can do a maximum of two (2) axis. The ACR1200 can be configured for a single (1) axis of commutation.

CHAPTER 1
Hardware Installation

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Chapter Overview

Description:

Hardware installation is located in the corresponding ACR1200 / ACR1500 / ACR2000 / ACR8000 / ACR8010 / ACR8020 Hardware Reference Manual.

ACR1200 Hardware Reference Manual: AMCS Part Number PM08123

ACR1500 Hardware Reference Manual: AMCS Part Number PM08122

ACR2000 Hardware Reference Manual: AMCS Part Number PM08117

ACR8000 Hardware Reference Manual: AMCS Part Number PM08119

ACR8010 Hardware Reference Manual: AMCS Part Number PM08121

ACR8020 Hardware Reference Manual: AMCS Part Number PM08126

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CHAPTER 2
System Reference

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Chapter Overview

Description:

This chapter gives an overview of the architecture of the Acroloop motion controllers' executive. This chapter must be read thoroughly before proceeding on to subsequent chapters.

The executive is a "pre-emptive" multi-tasking operating system. As many as 16 simultaneous tasks can be open at the same time. Each of these tasks are called "programs" and are referenced as PROG0 ... PROG15.

There are three communication channels (or streams) available on the ACR2000 / ACR8000 / ACR8010 that can be simultaneously open to send and receive data. They are as follows:

1. `COM1:` (Serial RS232, RS422)
2. `COM2:` (Serial RS232, RS422)
3. `FIFO:` (PC/ISA bus, port access)

There are two communication channels (or streams) available on the ACR1200 that can be simultaneously open to send and receive data. They are as follows:

1. `COM1:` (Serial RS232, RS422)
2. `COM2:` (Serial RS232, RS422)

There is one communication channel (or stream) available on the ACR1500 that can be open to send and receive data. This is as follows:

1. `FIFO:` (PC/ISA bus, port access)

There are three communication channels (or streams) available on the ACR8020 that can be simultaneously open to send and receive data. They are as follows:

1. `COM1:` (Serial RS232, RS422)
2. `COM2:` (Serial RS232, RS422)
3. `DPCB:` (PC/PCI bus, dual port circular buffer)

All of the above channels can be operated simultaneously and attached to various programs. Programs can be running while others are being edited.

All of the channels "wake-up" on power-up when seeing data. Additionally, the serial channels have automatic baud detection that is triggered by receiving one or two carriage returns (ASCII 13) after power-up.

Communication Channels

The user has the option of communicating with the ACR2000/ACR8000/ACR8010 through either the PC Bus or RS-232/RS-422 serial ports. The ACR1200 user can communicate through RS-232/RS-422 serial ports only. The ACR1500 user can communicate through the PC Bus only.

The ACR2000 requires the optional ACRCOMM module for serial communication.

There are three communication channels (or streams) available that can be simultaneously open to send and receive data. They are as follows:

1. `COM1:` (Serial RS232, RS422) (Not available on the ACR1500)
2. `COM2:` (Serial RS232, RS422) (Not available on the ACR1500)
3. `FIFO:` (PC/ISA bus, port access) (Not available on the ACR1200)

Communication Buffers:

As the commands are received by the boards, they are stored in an ASCII stream buffer. There is a stream buffer for each of the FIFO, COM1, and COM2 system tasks. The default buffer size is 256 bytes long.

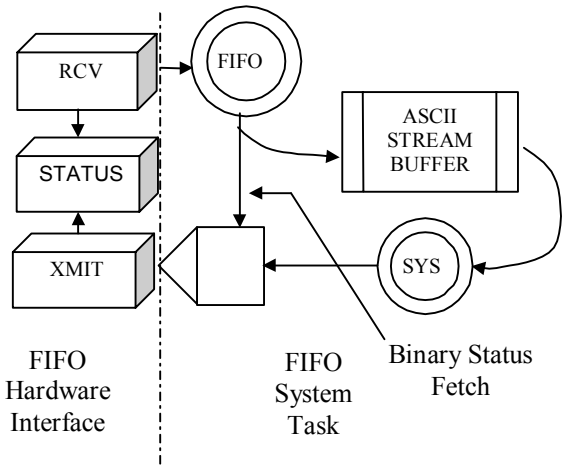


Figure 2.1 FIFO System Task

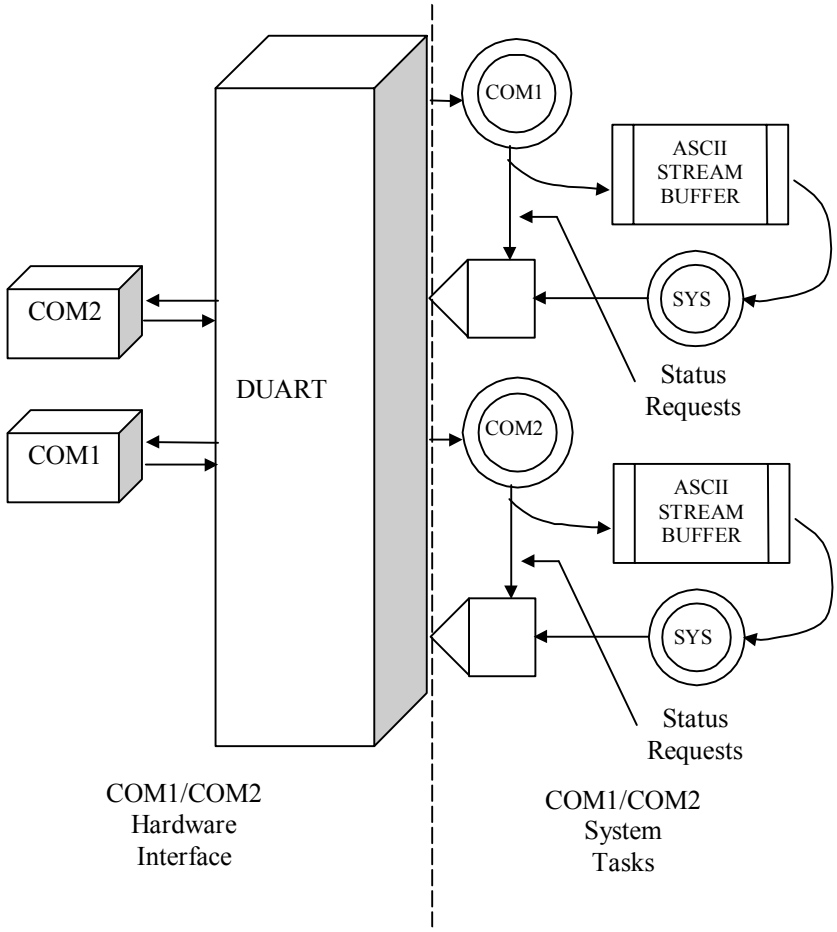


Figure 2.2 COM1/COM2 System Tasks

If the system task cannot process commands faster than the data coming in from the hardware interface by the front-end application, the ASCII buffer may become full. Once this happens, the corresponding task (COM1, COM2, FIFO) is suspended. This in turn will cause the hardware FIFOs to become full, causing the front-end application to timeout based on status flags (refer to appropriate hardware manual, Address Selection Switch (SW1) (ACR1500/ACR2000/ACR8000) or Plug and Play (ACR8010)).

ASCII buffer size (in bytes) can be changed by using the DIM command (see DIM command). ASCII buffer size is limited by the amount of User RAM memory available for dimensioning (see Memory Organization).

Communication Levels

Communication channels are either at the "system" level or at a "program" level. The command prompt indicates the level that a communication channel is currently at.

System Level:

The "system" level is the level that a communication channel is at after power-up. The command prompt at this level is as follows:

```
SYS>
```

Only a limited set of commands can be issued from this level. From any other level, the SYS command will return the communication channel to the system level.

Program Level:

This "program" level allows the editing and running of individual programs. The command prompt at the program level is as follows::

```
Pnn>
```

Where "nn" is the currently active program number. To select this level from any other level, issue the PROG command followed by the program number. For example, the following command will select program 1 no matter which level or program is currently active:

```
PROG 1
```

To go back to the system level from the program level, execute the SYS command. To go from one program to another program, simply issue another PROG command followed by the desired program number.

The following figure shows the various communication channel levels. The communication channels on the left can all be active at the same time and be operating at different levels. For example, "COM1:" could be editing program 3 while "COM2:" monitors user variables being modified by program number 5.

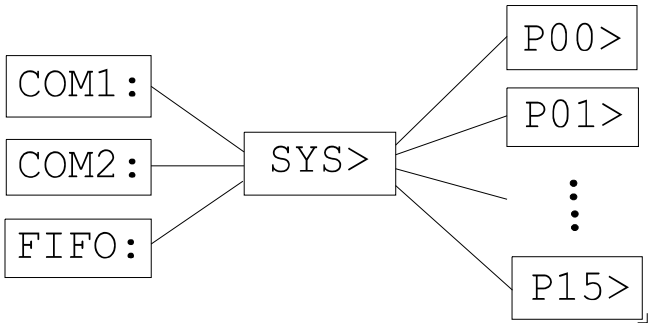


Figure 2.3 SYS / PROG levels

Multiple Board Communication

PC BUS:

Multiple board communication over the PC Bus is handled by using different I/O port addresses and card numbers for each card in the system. Refer to the appropriate ACR1500/ACR2000/ACR8000 hardware manual for Address Selection Switch (SW1) information. Refer to ACR8010 hardware manual for ACR8010 card Plug and Play information.

Up to eight ACR1500/ACR2000/ACR8000/ACR8010 boards can be used in the same system.

SERIAL BUS:

Multiple board communication over the serial ports is handled by using different card numbers for each card in the system, and using the ctrl-A and ctrl-B commands to address the cards. Refer to the appropriate ACR1200/ACR2000/ACR8000/ACR8010 hardware manual for Address Selection Switch (SW1) and Multiple Card Wiring information.

Up to eight ACR1200/ACR2000/ACR8000/ACR8010 board serial ports can be daisy-chained, creating a serial bus.

Symbol	Argument	Function
ctrl-A	# or <CR>	Turn on card # or all cards
ctrl-B	# or <CR>	Turn off card # or all cards

The ctrl-A and ctrl-B commands may be terminated by an ASCII character representing the card number, i.e. “0” represents the first card and the zero key on a keyboard, or by a carriage return (<CR>). A <CR> in this case means “all cards”. Other commands are terminated by a <CR>.

NOTE: Only one board should be enabled (turned on) at a time, to allow for proper handling of unsolicited responses (i.e., error messages, printing tasks, responses from LRUN command, etc.) from individual cards.

Usage Example:

The following example shows two cards (Card Number 0 and Card Number 1) being controlled via the serial port:

```
ctrl-B<CR>              Turn all cards off.
ctrl-A 0<CR>            Turn on Card Number 0.
PROG0<CR>               Program 0 for Card Number 0.
ACC 10<CR>              Set ACC to 10 for Card Number 0.
DEC 10<CR>              Set DEC to 10 for Card Number 0.
VEL 2000<CR>            Set VEL to 2000 for Card Number 0.
ctrl-B 0<CR>            Turn off Card Number 0.
ctrl-A 1<CR>            Turn on Card Number 1.
PROG2<CR>               Program 2 for Card Number 1.
ACC 10<CR>              Set ACC to 10 for Card Number 1.
DEC 10<CR>              Set DEC to 10 for Card Number 1.
VEL 1000                Set VEL to 1000 for Card Number 1.
```

System Attachments

The following is an overview of the "objects" involved in system attachment:

- On the ACR8010, there are ten input channels for reading incremental encoders. These are referenced as ENC0 through ENC9.
  On the ACR8000, there are eight input channels for reading incremental encoders. These are referenced as ENC0 through ENC7.
  On the ACR2000 and ACR1500, there are four input channels for reading incremental encoders. These are referenced as ENC0 through ENC3.
  On the ACR1200, there are three input channels for reading incremental encoders. These are referenced as ENC0 through ENC7.
- On the ACR8010/ACR8000, there are eight output channels for controlling the D/A converters. These are referenced as DAC0 through DAC7.
  On the ACR2000 and ACR1500, there are four output channels for controlling the D/A converters. These are referenced as DAC0 through DAC3.
  On the ACR1200, there are two output channels for controlling the D/A converters. These are referenced as DAC0 through DAC1.
- On the ACR8010/ACR8000, there are eight position interpolation and servo loop control units. These are referenced as AXIS0 through AXIS7.
  On the ACR2000 and ACR1500, there are four position interpolation and servo loop control units. These are referenced as AXIS0 through AXIS3.
  On the ACR1200, there are two position interpolation and servo loop control units. These are referenced as AXIS0 through AXIS1.
- On the ACR8010/ACR8000, there are eight master velocity profiles for controlling the axes. These are referenced as MASTER0 through MASTER7.
  On the ACR2000 and ACR1500, there are four master velocity profiles for controlling the axes. These are referenced as MASTER0 through MASTER3.
  On the ACR1200, there are two master velocity profiles for controlling the axes. These are referenced as MASTER0 through MASTER1.
- On the ACR8010/ACR8000, each master profiler has eight internal attachment points for axes. These are referenced as SLAVE0 through SLAVE7.
  On the ACR2000 and ACR1500, each master profiler has four internal attachment points for axes. These are referenced as SLAVE0 through SLAVE3.
  On the ACR1200, each master profiler has two internal attachment points for axes. These are referenced as SLAVE0 through SLAVE1.
- There are 16 programs with internal attachment points for masters. These are referenced as PROG0 through PROG15.

In order for an axis to do a motion profile in either MDI or program mode, it must be attached as the slave of a master and the master must be attached to a program. Axes are accessed with axis names of up to 4 characters in length. This name is assigned to the axis when it is attached to its master. See the ATTACH command for examples.

The question of how many masters to use and what axes to attach to it is largely a user choice made initially on the type of machine. If there are 6 axis in total and they are broken into two XYZ pick and place robots, then use two masters and two programs, attaching three axis to each of the masters. Since the axes are attached to different masters, they can be named X,Y and Z in both programs.

Once the relationship between a program, master, and axes has been established, it can be canceled by using the DETACH command.

Command Input Modes

Most commands can be executed either in MDI (Manual Data Input) mode or program mode (from within a stored program.) Some commands can only be issued as MDI commands and others can only appear in stored programs.

In MDI mode, the commands get executed immediately as they are entered while in the program mode, the commands are stored in memory as they are entered. They can be executed later by issuing a RUN command in the MDI mode. Program mode entry is not allowed from the system level.

Any command that is preceded by a valid line number will get stored into the memory of the currently selected program. Valid line numbers are in the range of 1..65000. Each line in a program must have a line number. These line numbers are also used as destination addresses for GOTO commands.

As an example, the following set of commands will do the identical motion profile but will illustrate the difference between the MDI mode and the program mode.

Program usage example:

```
PROG0
10 ACC 10000 DEC 10000 STP10000 VEL 20000
20 X100000
30 END
RUN
```

MDI usage example:

```
PROG0
ACC10000 DEC 10000 STP 10000 VEL 20000
X100000
```

Memory Organization

The following figures show the memory organization of the ACR1200/ACR1500/ACR2000/ACR8000/ACR8010 boards:

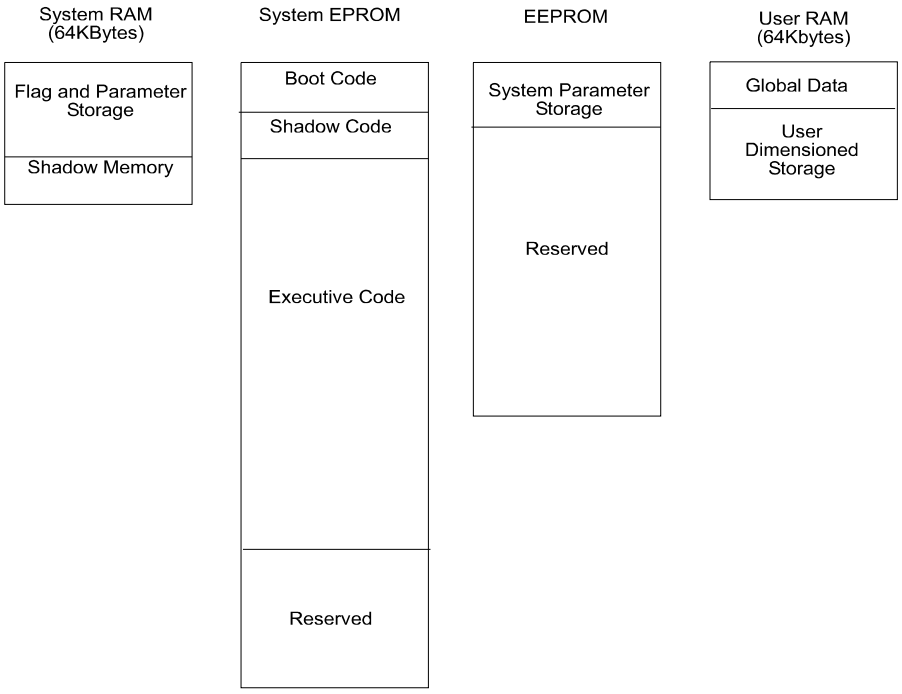


Figure 2.4 ACR8000 Memory Organization

Memory Organization

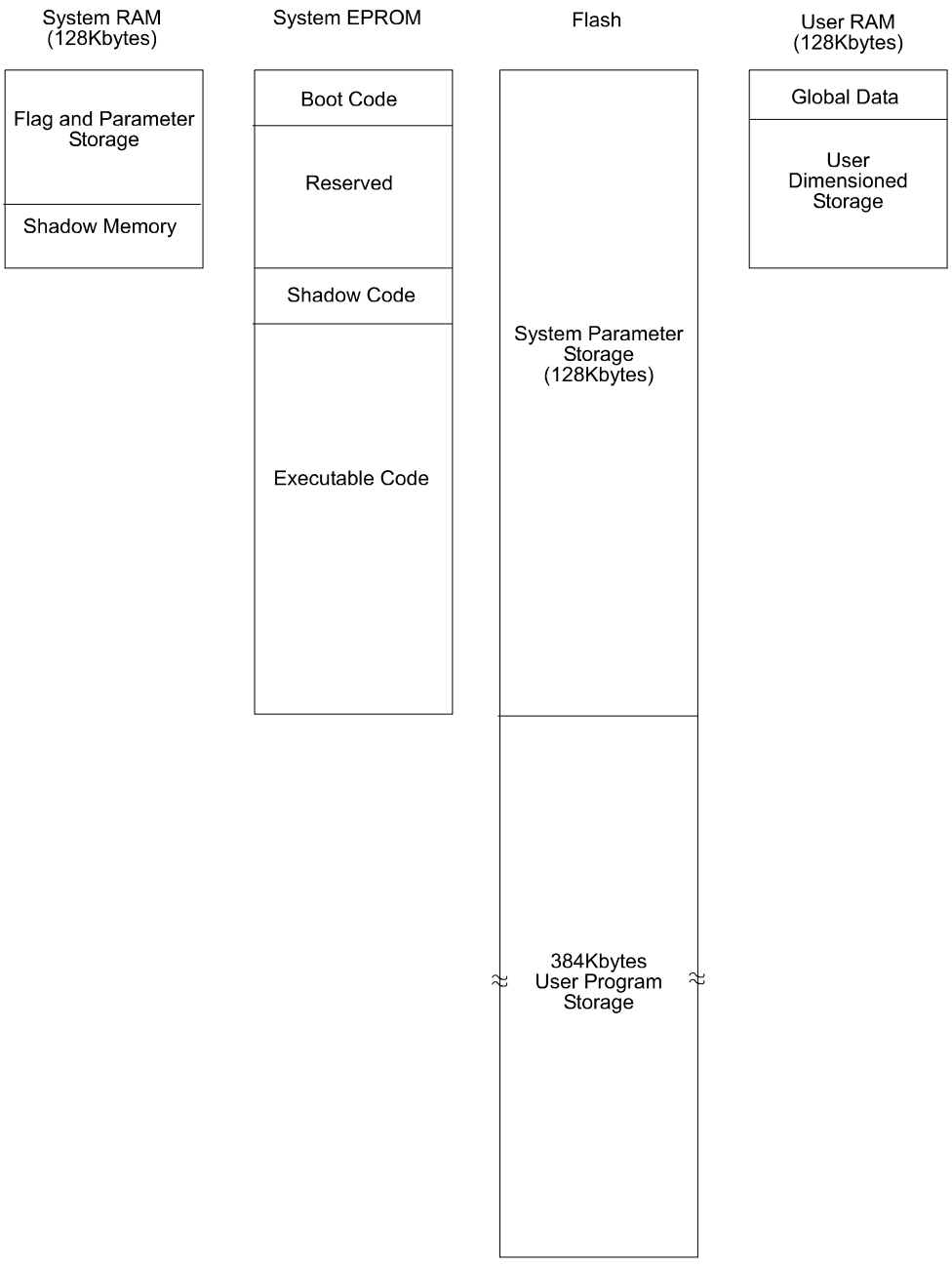


Figure 2.5 ACR1200, ACR1500, and ACR2000 Standard Memory Organization

Memory Organization

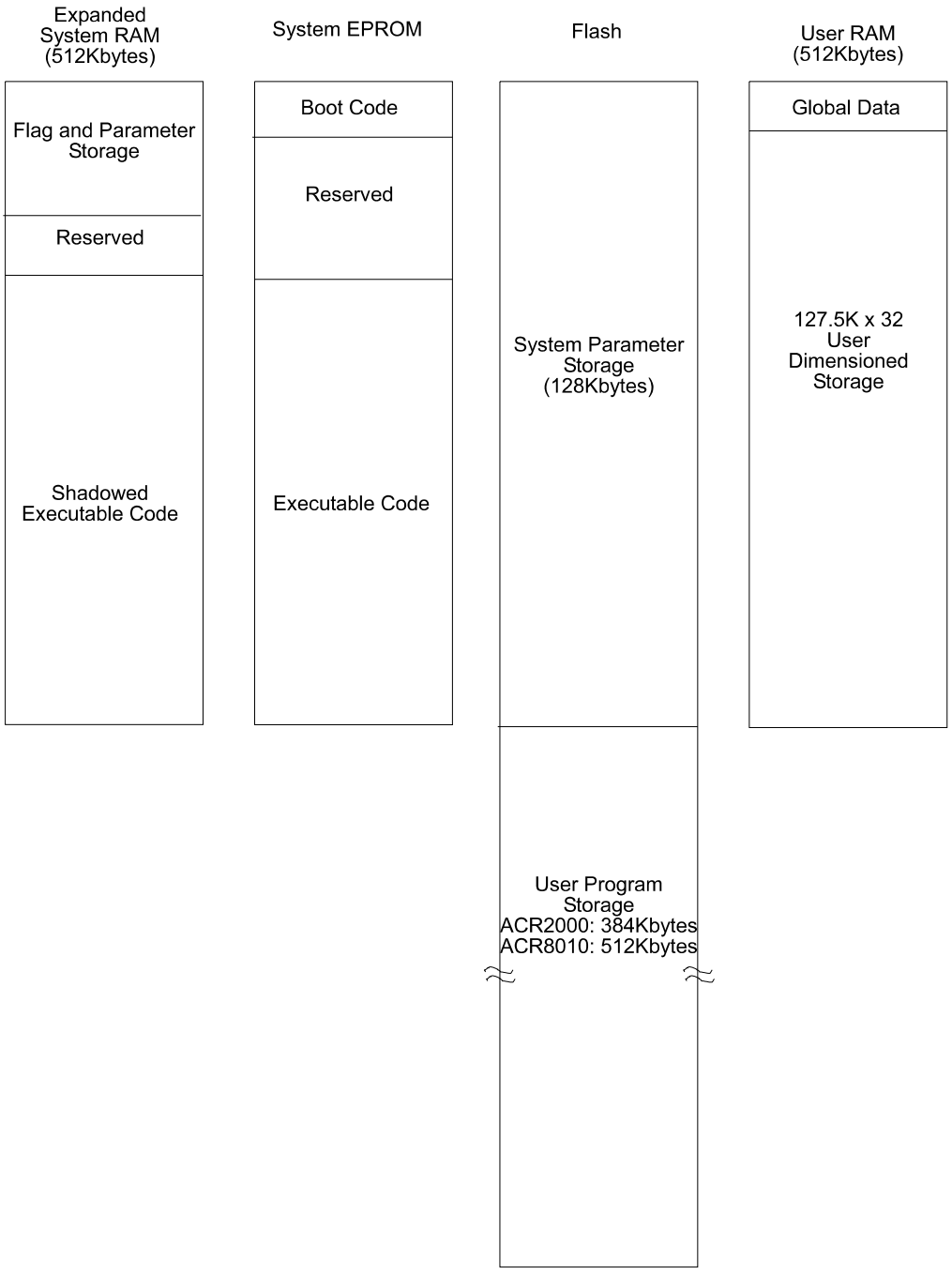


Figure 2.6 ACR8010 Memory Organization and ACR2000 Expanded Memory Organization

Memory Organization

There are five types of memory blocks in the ACR1200 / ACR1500 / ACR2000 / ACR8000 / ACR8010 memory organization as described below:

EPROM:

The EPROM is a Electrically Programmable Read Only Memory. The EPROM's main function is to store the executable firmware code. The EPROM is programmed at the factory and is not programmable by the user.

The EPROM-based code in the ACR8000 runs at one wait-state (148 ns using a 27MHz System Clock), at two wait-states for the ACR1200 and ACR1500 (150ns using a 40MHz System Clock), and at two wait-states for the Standard Memory ACR2000 (120 ns using a 50MHz System Clock). The code for the ACR8010 and the Expanded Memory ACR2000 does not run out of the EPROM, but out of the system RAM (see below).

The ACR8000, ACR1200, ACR1500, and Standard Memory ACR2000 EPROMs also contain a section of shadow code, which is loaded into the System RAM memory at power-up or reset. The ACR8010 and the Expanded Memory ACR2000 EPROM load all of the executable firmware code into the Expanded System RAM memory at power-up or reset. The code that is loaded into RAM runs at zero wait-states.

System RAM:

The System RAM is Static Random Access Memory. This memory is not battery backed-up.

The System RAM's functions are to store system parameters and flag information and to store the shadow code, which is copied into the System RAM from the EPROM by the DSP.

The System RAM runs at zero wait-state for the ACR8000 (74 ns using a 27MHz System Clock), the ACR1200 and ACR1500 (50 ns using a 40MHz System Clock), and Standard Memory ACR2000 (40 ns using a 50MHz System Clock). This allows fast access by the DSP for the system parameters and flags information, as well as the speed critical shadow code for the main servo system interrupt.

The executable code for the ACR8010 and the Expanded Memory ACR2000 is copied into the System RAM from the EPROM by the DSP. All of the executable code then runs at zero wait-state (40 ns using a 50MHz System Clock for Expanded Memory ACR2000, 33 ns using a 60MHz System Clock for ACR8010), which increases system performance.

Memory Organization

User RAM:

The User RAM is battery backed-up Static Random Access Memory for the ACR1200, ACR8000, and the ACR8010 board. This memory is battery backed-up for ACR2000 boards with the ACRCOMM Module option.

The main function of the User Ram is to store user information. The user determines what is stored into these memories by using the DIM command. User programs, PLC programs, FIFO, COM1, and COM2 stream buffers, CAM and ballscrew tables, global variables, program variables, and program arrays are all stored in these memories.

There is also dedicated section of User RAM which stores Global Data. The global data provides User RAM locations and dimensioning information, which is used by the DSP, for all of the above user data.

This memory is not battery backed-up for ACR1500 boards or ACR2000 boards without the ACRCOMM Module option. The user must load the data each time the board is powered-up.

EEPROM:

The EEPROM is an Electrically Erasable Programmable Read-Only Memory on the ACR8000 board.

The EEPROM's functions include storing system parameters and board configuration information.

System parameters are stored using the ESAVE command and loaded into the card using the ELOAD command. System parameters can be updated in the EEPROM by first erasing the existing parameters, using the ERASE command, and then using the ESAVE command to store the new information.

The system parameters stored in the EEPROM using the ESAVE command include system attachments, master parameters (ACC, DEC, and STP ramps, and VEL, FVEL, and IVEL values), axis parameters (gain and limit setting, PPU and VECDEF values, and ON/OFF states), encoder multipliers, DAC gains and offsets, and ADC gains and offsets.

Board configuration information is stored when the CONFIG commands are used.

Memory Organization

Flash:

The Flash is an Electrically Erasable Programmable Read-Only Memory on the ACR1200, ACR1500, ACR2000, and ACR8010 boards.

The Flash's functions include storing system parameters, board configuration information and user programs.

System parameters are stored using the ESAVE command and loaded into the card using the ELOAD command. System parameters can be updated in the Flash by first erasing the existing parameters, using the ERASE command, and then using the ESAVE command to store the new information.

The system parameters stored in the Flash using the ESAVE command include system attachments, master parameters (ACC, DEC, and STP ramps, and VEL, FVEL, and IVEL values), axis parameters (gain and limit setting, PPU and VECDEF values, and ON/OFF states), encoder multipliers, DAC gains and offsets, and ADC gains and offsets.

Board configuration information is stored when the CONFIG commands are used.

Program storage uses the FLASH commands (FLASH LOAD, FLASH ERASE, FLASH SAVE, FLASH IMAGE). At power-up or reset, the DSP detects if programs are present in the Flash, and if they are present, loads them into User RAM, overwriting any battery back-up programs. The tables, buffers, variables and arrays stored in the User RAM are not written over.

Memory Organization

The following table shows the type(s) of memory associated with system commands:

COMMAND	System RAM	User RAM	EPROM	EEPROM/ Flash	N/A
ACC	X			X	
ADC	X			X	
ADCX	X			X	
ALM	X			X	
ATTACH	X			X	
AUT					X
AXIS	X			X	
BKL	X				
BLK					X
BLM	X				
BRESET		X			
BSC		X			
CAM		X			
CIRCCW	X				
CIRCW	X				
CLEAR		X			
CLOSE	X				
CLR	X				
CMT	X			X	
CONFIG				X	
CPU					X
DAC	X			X	
DEC	X			X	
DEF		X			
DEFINE		X			
DETACH	X			X	
DGAIN	X			X	
DIAG					X
DIM		X			
DIN	X				
DIP	X				
DWIDTH	X			X	
DWL					X
DZL	X				
DZU	X				
ECHO					X
ELOAD				X	
ENC	X			X	
ENC RD ABS	X			X	
END					X
ERASE				X	
ESAVE				X	
EXC	X				
F	X				
FBVEL	X			X	
FFACC	X			X	

COMMAND	System RAM	User RAM	EPROM	EEPROM/ Flash	N/A
FFVEL	X			X	
FFVC	X				
FLASH				X	
FLT	X				
FLZ	X				
FOR	X				
FOV	X				
FVEL	X			X	
FSTAT	X				
GEAR		X			
GOSUB					X
GOTO					X
HALT					X
HDW	X				
HELP					X
HSINT	X				
IDELAY	X			X	
IF / THEN					X
IF / ELSE /ENDIF					X
IGAIN	X			X	
IHPOS	X				
ILIMIT	X			X	
INH					X
INPUT					X
INT	X				
INTCAP	X				
INVK	X				
IPB	X			X	
ITB	X			X	
IVEL	X			X	
JLM	X			X	
JOG	X			X	
JRK	X				
KVF	X				
KVI	X				
KVP	X				
LIMIT	X				
LIST					X
LISTEN					X
LOCK					X
LOOK	X				
LOPASS	X				
LRUN					X
MASK	X				
MASTER	X			X	
MAXVEL	X				
MBUF		X			
MEM		X			
MODE					X
MOV	X				
MSEEK	X				
MULT	X			X	

COMMAND	System RAM	User RAM	EPROM	EEPROM/ Flash	N/A
NEW		X			
NORM	X				
NOTCH	X				
NURB	X				
OFFSET	X				
OPEN					X
PASSWORD	X				
PAUSE					X
PBOOT		X			
PERIOD	X				
PGAIN	X			X	
PLC		X			
PLS	X				
PPU	X			X	
PROG		X			
PROGRAM		X			
PROM		X	X		
RATCH	X				
REBOOT					X
REM					X
REN	X				
RES	X				
RESUME					X
RETURN					X
ROTARY	X				
ROTATE	X				
ROV	X				
RUN					X
SAMP		X			
SCALE	X				
SET	X				
SINE	X				
SPLINE	X				
SRC	X				
STEP					X
STP	X			X	
SYNC	X		X		
SYS					X
TANG	X				
TARC	X				
TLM	X			X	
TMOV	X				
TOV	X				
TRG	X				
TRJ	X				
TROFF					X
TRON					X
UNLOCK					X
VECDEF	X			X	
VECTOR	X				
VEL	X			X	
VER		X	X		

COMMAND	System RAM	User RAM	EPROM	EEPROM/ Flash	N/A
WHILE					X

Variable Memory Allocation

For the following definitions, xxx and yyy are positive numbers. Their range depends on memory limitations. There are two sets of memory types that are accessible by each program, global system and local user parameters.

The global system parameter definitions are listed in Chapter 6. Each parameter number is preceded by the letter "P". For example, the following command will load system parameter 4097 with the value 123:

```
P4097 = 123
```

In addition to the global system parameters that can be accessed by all programs, each program can dimension (allocate) local parameters. These parameters can be either single variables or arrays of variables.

The following formats are used to access the different types of variables:

Pxxx	Global system variable xxx.
BITxxx	Global bit flag xxx
LVxxx	Local Long (32 bit integer) variable xxx.
LAxxx(yyy)	Local Long array number xxx and index yyy.
SVxxx	Local Single (32 bit floating point) variable xxx.
SAxxx(yyy)	Local Single array number xxx and index yyy.
DVxxx	Local Double (64 bit floating point) variable xxx.
DAxxx(yyy)	Local Double array number xxx and index yyy.
$Vxxx	Local String (packed 8 bit) variable xxx.
$Axxx(yyy)	Local String array number xxx and index yyy.

Global user variables are referenced as P0..P4095. The actual number of global user variables is determined by the DIM P command from the system level. Global system parameters are referenced according to the tables in Appendix A.

Local user variables are referenced by their type, followed by a number. The following command will load the number 1234 into the first long integer variable:

```
LV0 = 1234
```

The local arrays are referenced by an array number and index. The following command will load the number 1234 into the fifth element of the first long integer array:

```
LA0(4) = 1234
```

Only the amount of memory remaining limits how many parameters can be allocated. The DIM command is used to declare the parameters and the CLEAR command to release them. Full floating point math is allowed to operate on global and local variables.

Parametric Evaluation

There is a built-in floating point evaluator that operates on the global and local variables. The following operators are available:

Arithmetic:	`+ - * / **`
Trigonometric:	`SIN COS TAN ATAN ACOS ASIN`
Hyperbolic:	`SINH COSH TANH ATANH ACOSH ASINH`
Logarithmic:	`LOG LN`
Comparison:	`= <> < > >= <=`
Logical:	`AND OR XOR NAND NOR XNOR NOT << >>`
Miscellaneous:	`SQRT RND`

String:	`CHR$ ASC LEN STR$ VAL INSTR`
	`LCASE$ UCASE$ SPACE$ STRING$`
	`LEFT$ RIGHT$ MID$ INKEY$ KBHIT`

The following are an example of valid statements assuming that the parameters have been properly dimensioned and the X and Y attachments have been defined:

```
LV1 = LV2+LV3*(LV5+LV6)
IF ((LV5+LV6*LV9) < 10 ) THEN GOTO 100
X(LV1+LV2) Y(3*LV5)
```

Note that the arguments of X and Y are enclosed in parentheses. This is the way that parametric arguments are given to a command. All commands will accept parametric arguments.

A special character is used to signify incremental distance for axis moves. This character is the forward slash "/". It must precede the numerical or parametric argument for incremental axis moves. As an example, the following command will move the X axis 20 units in the positive direction from its current location:

```
X /20
```

It is possible to mix absolute, incremental, and parametric moves as follows:

```
X2.5 Y/1.23 Z/(DV2*DV3)
```

Servo Loop

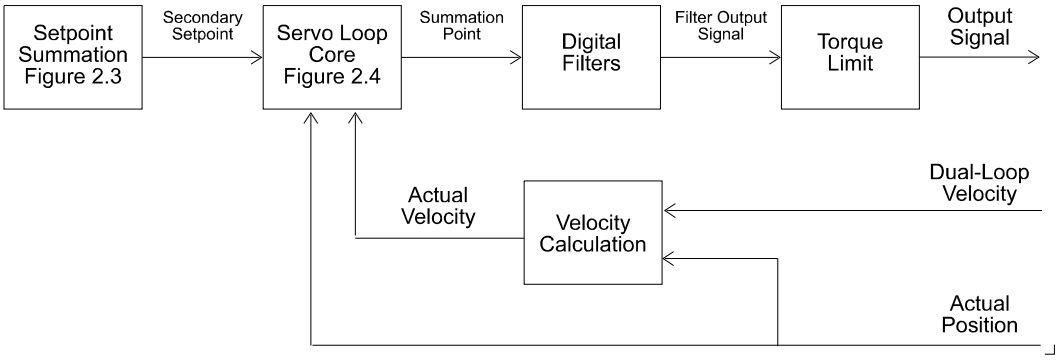


Figure 2.7 Servo loop

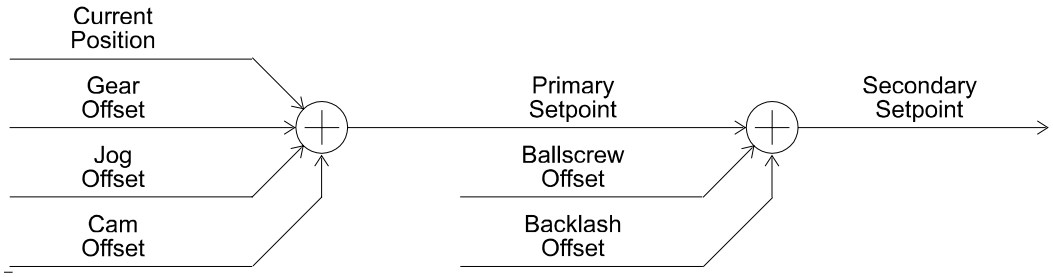


Figure 2.8 Setpoint summation

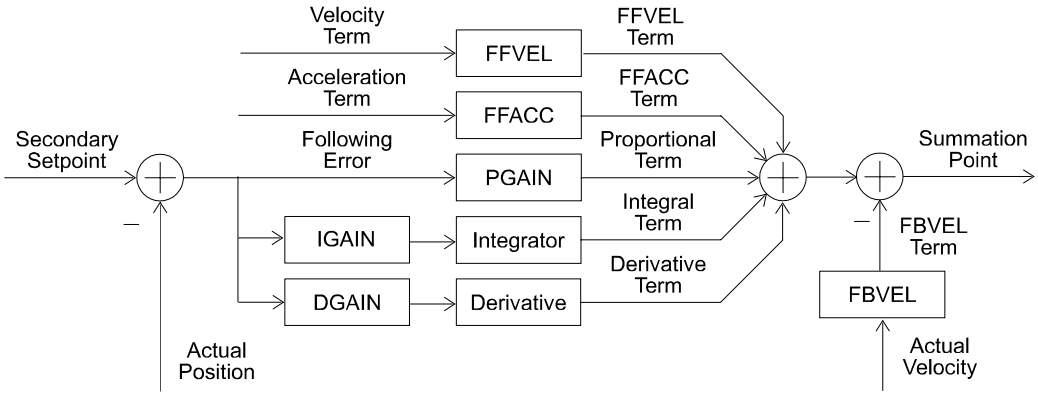
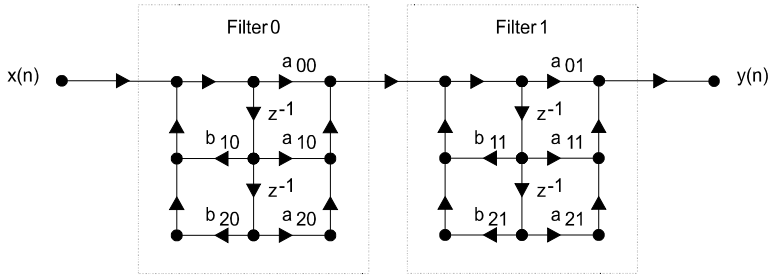


Figure 2.9 Servo loop core

Digital Filters

Filter Equations:



$$H(z) = \left(\frac{a_{00} + a_{10} z^{-1} + a_{20} z^{-2}}{1 - b_{10} z^{-1} - b_{20} z^{-2}} \right) \left(\frac{a_{01} + a_{11} z^{-1} + a_{21} z^{-2}}{1 - b_{11} z^{-1} - b_{21} z^{-2}} \right)$$

Figure 2.10 Filter equations

Filter Parameters:

Filter 0	Axis Number							
	0	1	2	3	4	5	6	7
b2 Coefficient	12336	12592	12848	13104	13360	13616	13872	14128
a2 Coefficient	12337	12593	12849	13105	13361	13617	13873	14129
b1 Coefficient	12338	12594	12850	13106	13362	13618	13874	14130
a1 Coefficient	12339	12595	12851	13107	13363	13619	13875	14131
a0 Coefficient	12340	12596	12852	13108	13364	13620	13876	14132

Filter 1	Axis Number							
	0	1	2	3	4	5	6	7
b2 Coefficient	12341	12597	12853	13109	13365	13621	13877	14133
a2 Coefficient	12342	12598	12854	13110	13366	13622	13878	14134
b1 Coefficient	12343	12599	12855	13111	13367	13623	13879	14135
a1 Coefficient	12344	12600	12856	13112	13368	13624	13880	14136
a0 Coefficient	12345	12601	12857	13113	13369	13625	13881	14137

Table 2.1 Digital filter parameters

Filter Flags:

Control	Axis Number							
	0	1	2	3	4	5	6	7
Filter Activate	786	818	850	882	914	946	978	1010

Table 2.2 Digital filter flags

Position Velocity Servo Loop

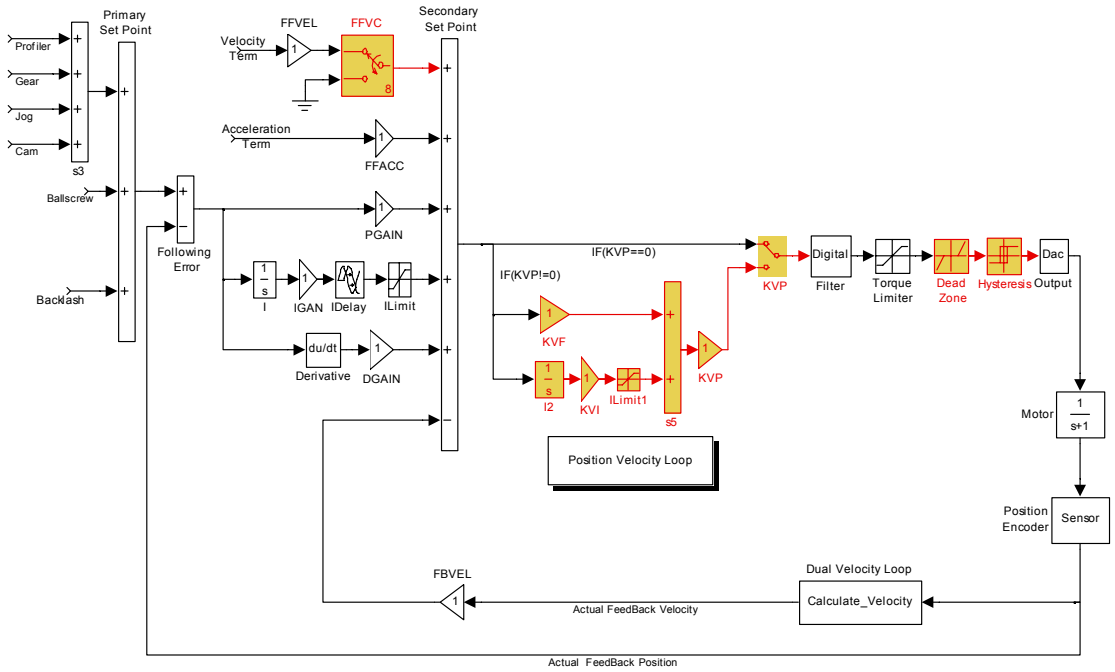


Figure 2.11 Servo loop with Dead Band and Position Velocity Loop

CHAPTER 3
Command Reference

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Command Groups

Axis Limits

ALM	Set stroke limit ‘A’
BLM	Set stroke limit ‘B’
EXC	Set excess error band
IPB	Set in-position band
ITB	Set in-torque band
JLM	Set jog limits
MAXVEL	Set velocity limits
TLM	Set torque limits

Character I/O

CLOSE	Close a device
INPUT	Receive data from a device
OPEN	Open a device
PRINT	Send data to a device

Feedback Control

HSINT	High Speed Interrupt
INTCAP	Encoder capture
MSEEK	Marker seek operation
MULT	Set encoder multipliers
NORM	Normalize current position
PPU	Set axis pulse/unit ratio
REN	Match position with encoder
RES	Reset or preload encoder
ROTARY	Set rotary axis length

Global Objects

ADC	Analog input control
AXIS	Direct axis access
DAC	Analog output control
ENC	Quadrature input control
ENC RD ABS	Yaskawa absolute encoder interface
LIMIT	Frequency Limiter
MASTER	Direct master access
PLS	Programmable limit switch
RATCH	Software ratchet
SAMP	Data sampling control
CMT	Commutator

Command Groups

(continued)

Logic Function

CLR	Clear a bit flag
DWL	Delay for a given period
IHPOS	Inhibit on position
INH	Inhibit on bit high or low
MASK	Safe bit masking
SET	Set a bit flag
TRG	Start move on trigger

Memory Control

CLEAR	Clear memory allocation
DIM	Allocate memory
MEM	Display memory allocation

Nonvolatile

BRESET	Disable battery backup
ELOAD	Load system parameters
ERASE	Clear the EEPROM
ESAVE	Save system parameters
PBOOT	Auto-run program
FLASH	Create user image in flash
PROM	Create burner image
FIRMWARE	Firmware upgrade/backup

Operating System

ATTACH	Define attachments
CONFIG	Hardware configuration
CPU	Display processor loading
DEF	Display user defined variables
DEFINE	Define user variables
DETACH	Clear attachments
DIAG	Display system diagnostics
ECHO	Character echo control
HELP	Display command list
MODE	Binary data formatting
PASSWORD	Block uploading programs from board.
PERIOD	Set base system timer period
PLC	Switch to a PLC prompt
PROG	Switch to a program prompt
REBOOT	Reboot controller card
SYS	Return to system prompt
VER	Display firmware version

Command Groups

(continued)

Program Control

AUT	Turn off block mode
BLK	Turn on block mode
HALT	Halt an executing program
LIST	List a stored program
LISTEN	Listen to program output
LRUN	Run and listen to a program
NEW	Clear out a stored program
PAUSE	Activate pause mode
PROGRAM / ENDP	Mark start and end of program without line numbers.
RESUME	Release pause mode
RUN	Run a stored program
STEP	Step in block mode
TROFF	Turn off trace mode
TRON	Turn on trace mode

Program Flow

END	End of program execution
FOR	Counter loop
GOTO	Branch to a new line number
GOSUB	Branch to a subroutine
IF / THEN	Conditional execution
REM	Program comment
RETURN	Return from a subroutine
WHILE	Conditional loop.

Servo Control

DGAIN	Set derivative gain
DIP	Dead Zone integrator positive value
DIN	Dead Zone integrator negative value
DWIDTH	Set derivative sample period
DZL	Dead Zone inner band
DZU	Dead Zone outer band
FBVEL	Set feed back velocity
FFACC	Set feed forward acceleration
FFVC	Feedforwad velocity cutoff region
FFVEL	Set feed forward velocity
FLT	Digital filter move
IDELAY	Set integral time-out delay
IGAIN	Set integral gain
ILIMIT	Set integral anti-windup limit
KVF	PV loop feedforward gain
KVI	PV loop integral gain
KVP	PV loop proportional gain
LOPASS	Setup lopass filter
NOTCH	Setup notch filter
PGAIN	Set proportional gain

Command Groups

(continued)

Setpoint Control

BKL	Set backlash compensation
BSC	Ballscrew compensation
CAM	Electronic cam
GEAR	Electronic gearing
HDW	Handwheel
JOG	Single axis velocity profile
LOCK	Lock gantry axis
UNLOCK	Unlock gantry axis

Transformation

FLZ	Relative program path shift
OFFSET	Absolute program path shift
ROTATE	Rotate a programmed path
SCALE	Scale a programmed path
INVK	Inverse Kinematics

Velocity Profile

ACC	Set acceleration ramp
DEC	Set deceleration ramp
F	Set velocity in units/minute
FOV	Set feedrate override
FVEL	Set final velocity
IVEL	Set initial velocity
JRK	Set jerk parameter (scurve)
LOOK	Look Ahead mode
MBUF	Multiple move buffer mode
ROV	Set rapid feedrate override
SRC	Set external timebase
STP	Set stop ramp
SYNC	Synchronization mode
TMOV	Set time based move
TOV	Time Override
VECDEF	Define automatic vector
VECTOR	Set manual vector
VEL	Set target velocity for a move

Interpolation

CIRCCW	Counter clockwise circular move
CIRCW	Clockwise circular move
INT	Interruptible move
MOV	Define a linear move
NURB	NURBs interpolation mode
SINE	Sinusoidal move
SPLINE	Spline interploation mode
TANG	Tangential move mode
TARC	3-D circular interpolation

TRJ	Start new trajectory

Command Cross Reference

The following table shows the commands available for each of the Acroloop Motion Controller family of boards. This table also indicates at what firmware level a command has been added above the base firmware level 1.13.03, as well as what firmware level that the boards have been added.

For the commands that have sub-commands (i.e. ADC), these sub-commands are only listed when there are different levels of firmware versions and/or board compatiblity.

An "✓" indicates that this command is valid for the board.

Command	Version Added (above 1.13.03)	ACR1200 (1.18.02)	ACR1500 (1.18.02)	ACR2000 (1.17.04)	ACR8000	ACR8010 (1.18)	ACR8020 (1.18.06 Upd09)
ACC		✓	✓	✓	✓	✓	✓
ADC				X			
MODE	1.18	✓	✓	X	✓	✓	✓
MAX	1.18	✓	✓	X	✓	✓	✓
SCALE	1.18	✓	✓		✓	✓	✓
POS		✓	✓	✓	✓	✓	✓
NEG		✓	✓	✓	✓	✓	✓
GAIN		✓	✓	✓	✓	✓	✓
OFFSET		✓	✓	✓	✓	✓	✓
ON		✓	✓	✓	✓	✓	✓
OFF		✓	✓	✓	✓	✓	✓
		✓	✓	✓	✓	✓	✓
ADCX	1.18.07	X	X	X	X	X	✓
ALM		✓	✓	✓	✓	✓	✓
ATTACH		✓	✓	✓	✓	✓	✓
AUT		✓	✓	✓	✓	✓	✓
AXIS		✓	✓	✓	✓	✓	✓
BKL		✓	✓	✓	✓	✓	✓
BLK		✓	✓	✓	✓	✓	✓
BLM		✓	✓	✓	✓	✓	✓
BRESET		✓	✓	✓	✓	✓	✓
BSC		✓	✓	✓	✓	✓	✓
CAM							
CAM ON TRG	1.18.04	✓	✓	✓	X	✓	✓
SRC RES	1.18.06	✓	✓	✓	X	✓	✓
CLEAR	1.18.06	✓	✓	✓	X	✓	✓
TRGP	1.18.06 upd12	✓	✓	✓	X	✓	✓
ALL OTHERS		✓	✓	✓	✓	✓	✓
CIRCCW	1.18.06	✓	✓	✓	X	✓	✓
CIRCW	1.18.06	✓	✓	✓	X	✓	✓
CLEAR		✓	✓	✓	✓	✓	✓
CLOSE		✓	✓	✓	✓	✓	✓
CLR		✓	✓	✓	✓	✓	✓
CMT	1.18	✓	✓	✓	X	✓	✓
CONFIG							
CLEAR	1.17.03	✓	✓	✓	✓	✓	✓
IO	1.17.03	✓	X	✓	✓	✓	✓
XIO	1.17.03	✓	X	✓	✓	✓	✓

Command	Version Added (above 1.13.03)	ACR1200 (1.18.02)	ACR1500 (1.18.02)	ACR2000 (1.17.04)	ACR8000	ACR8010 (1.18)	ACR8020 (1.18.06 Upd09)
IO MODE	1.18.02	X	✓		X	X	X
IO INPUT	1.18.02	X	✓		X	X	X
IO OUT	1.18.02	X	✓		X	X	X
CPU		✓	✓	✓	✓	✓	✓
DAC		✓	✓	✓	✓	✓	✓
DEC		✓	✓	✓	✓	✓	✓
DEF	1.18.07	✓	✓	✓	✓	✓	✓
DEFINE	1.18.07	✓	✓	✓	✓	✓	✓
DETACH		✓	✓	✓	✓	✓	✓
DGAIN		✓	✓	✓	✓	✓	✓
DIAG		✓	✓	✓	✓	✓	✓
DIM							
PROG		✓	✓	✓	✓	✓	✓
PLC		✓	✓	✓	✓	✓	✓
P		✓	✓	✓	✓	✓	✓
FIFO	1.17.03	✓	✓	✓	✓	✓	✓
COM1	1.17.03	✓	✓	✓	✓	✓	✓
COM2	1.17.03	✓	✓	✓	✓	✓	✓
LOGGING	1.18.00	✓	✓	✓	✓	✓	✓
MBUF	1.18.06	✓	✓	✓	X	✓	✓
		✓	✓	✓	X	✓	✓
DIN	1.18.06 upd9	✓	✓	✓	X	✓	✓
DIP	1.18.06 upd9	✓	✓	✓	X	✓	✓
DWIDTH		✓	✓	✓	✓	✓	✓
DWL		✓	✓	✓	✓	✓	✓
DZL	1.18.06 upd9	✓	✓	✓	X	✓	✓
DZU	1.18.06 upd9	✓	✓	✓	X	✓	✓
ECHO		✓	✓	✓	✓	✓	✓
ELOAD		✓	✓	✓	✓	✓	✓
ENC		✓	✓	✓	✓	✓	✓
ENC RD ABS	1.18.04	X	X	X	X	✓	✓
END		✓	✓	✓	✓	✓	✓
ERASE		✓	✓	✓	✓	✓	✓
ESAVE		✓	✓	✓	✓	✓	✓
EXC		✓	✓	✓	✓	✓	✓
F		✓	✓	✓	✓	✓	✓
FBVEL		✓	✓	✓	✓	✓	✓
FFACC		✓	✓	✓	✓	✓	✓
FFVC	1.18.06 upd9	✓	✓	✓	X	✓	✓
FFVEL		✓	✓	✓	✓	✓	✓
FLASH							
LOAD		✓	✓	✓	X	✓	✓
SAVE		✓	✓	✓	X	✓	✓
IMAGE	1.17.07	✓	✓	✓	X	✓	✓
ERASE		✓	✓	✓	X	✓	✓
FLT	1.18.06	✓	✓	✓	X	✓	✓
FLZ		✓	✓	✓	✓	✓	✓
FOV		✓	✓	✓	✓	✓	✓
FOR / NEXT	1.18.07	✓	✓	✓	✓	✓	✓
FVEL		✓	✓	✓	✓	✓	✓
FSTAT	1.18.06 upd9	X	X	X	X	X	✓
GEAR							

Command	Version Added (above 1.13.03)	ACR1200 (1.18.02)	ACR1500 (1.18.02)	ACR2000 (1.17.04)	ACR8000	ACR8010 (1.18)	ACR8020 (1.18.06 Upd09)
TRG	1.18.06 upd12	✓	✓	✓	X	✓	✓
TRGP	1.18.06 upd12	✓	✓	✓	X	✓	✓
ALL OTHERS		✓	✓	✓	✓	✓	✓
GOSUB		✓	✓	✓	✓	✓	✓
GOTO		✓	✓	✓	✓	✓	✓
HALT		✓	✓	✓	✓	✓	✓
HDW		✓	✓	✓	✓	✓	✓
HELP		✓	✓	✓	✓	✓	✓
HSINT	1.16.09	✓	✓	✓	✓	✓	✓
IDELAY		✓	✓	✓	✓	✓	✓
IF / THEN		✓	✓	✓	✓	✓	✓
IF / ELSE /ENDIF	1.18.07	✓	✓	✓	✓	✓	✓
IGAIN		✓	✓	✓	✓	✓	✓
IHPOS		✓	✓	✓	✓	✓	✓
ILIMIT		✓	✓	✓	✓	✓	✓
INH		✓	✓	✓	✓	✓	✓
INPUT		✓	✓	✓	✓	✓	✓
INT		✓	✓	✓	✓	✓	✓
INTCAP							
Fixed Registers		✓	✓	✓	✓	✓	✓
Register Select	1.18	✓	✓	✓	X	✓	✓
INVK	1.18.07	✓	✓	✓	✓	✓	✓
IPB		✓	✓	✓	✓	✓	✓
ITB		✓	✓	✓	✓	✓	✓
IVEL		✓	✓	✓	✓	✓	✓
JLM		✓	✓	✓	✓	✓	✓
JOG		✓	✓	✓	✓	✓	✓
JRK		✓	✓	✓	✓	✓	✓
KVF	1.18.06 upd9	✓	✓	✓	X	✓	✓
KVI	1.18.06 upd9	✓	✓	✓	X	✓	✓
KVP	1.18.06 upd9	✓	✓	✓	X	✓	✓
LIMIT		✓	✓	✓	✓	✓	✓
LIST		✓	✓	✓	✓	✓	✓
LISTEN		✓	✓	✓	✓	✓	✓
LOCK		✓	✓	✓	✓	✓	✓
LOOK	1.18.06	✓	✓	✓	X	✓	✓
LOPASS		✓	✓	✓	✓	✓	✓
LRUN		✓	✓	✓	✓	✓	✓
MASK	1.16.06	✓	✓	✓	✓	✓	✓
MASTER		✓	✓	✓	✓	✓	✓
MAXVEL	1.18.04	✓	✓	✓	X	✓	✓

Command	Version Added (above 1.13.03)	ACR1200 (1.18.02)	ACR1500 (1.18.02)	ACR2000 (1.17.04)	ACR8000	ACR8010 (1.18)	ACR8020 (1.18.06 Upd09)
MBUF	1.18.06	✓	✓	✓	X	✓	✓
MEM		✓	✓	✓	✓	✓	✓
MODE		✓	✓	✓	✓	✓	✓
MOV		✓	✓	✓	✓	✓	✓
MSEEK		✓	✓	✓	✓	✓	✓
MULT		✓	✓	✓	✓	✓	✓
NEW		✓	✓	✓	✓	✓	✓
NORM		✓	✓	✓	✓	✓	✓
NOTCH		✓	✓	✓	✓	✓	✓
NURB	1.18.04	✓	✓	✓	X	✓	✓
OFFSET		✓	✓	✓	✓	✓	✓
OPEN		✓	✓	✓	✓	✓	✓
PASSWORD	1.18.06 Upd 9	✓	✓	✓	X	✓	✓
PAUSE		✓	✓	✓	✓	✓	✓
PBOOT		✓	✓	✓	✓	✓	✓
PERIOD		✓	✓	✓	✓	✓	✓
PGAIN		✓	✓	✓	✓	✓	✓
PLC		✓	✓	✓	✓	✓	✓
PLS		✓	✓	✓	✓	✓	✓
PPU		✓	✓	✓	✓	✓	✓
PROG		✓	✓	✓	✓	✓	✓
PROGRAM / ENDP	1.18.07	✓	✓	✓	✓	✓	✓
PROM		✓	X	✓	✓	✓	✓
RATCH		✓	✓	✓	✓	✓	✓
REBOOT		✓	✓	✓	✓	✓	✓
REM		✓	✓	✓	✓	✓	✓
REN		✓	✓	✓	✓	✓	✓
RES		✓	✓	✓	✓	✓	✓
RESUME		✓	✓	✓	✓	✓	✓
RETURN		✓	✓	✓	✓	✓	✓
ROTARY		✓	✓	✓	✓	✓	✓
ROTATE		✓	✓	✓	✓	✓	✓
ROV	1.17.05	✓	✓	✓	✓	✓	✓
RUN		✓	✓	✓	✓	✓	✓
SAMP		✓	✓	✓	✓	✓	✓
SCALE		✓	✓	✓	✓	✓	✓
SET		✓	✓	✓	✓	✓	✓
SINE		✓	✓	✓	✓	✓	✓
SPLINE	1.18.04	✓	✓	✓	X	✓	✓

Command	Version Added (above 1.13.03)	ACR1200 (1.18.02)	ACR1500 (1.18.02)	ACR2000 (1.17.04)	ACR8000	ACR8010 (1.18)	ACR8020 (1.18.06 Upd09)
SRC		✓	✓	✓	✓	✓	✓
STEP		✓	✓	✓	✓	✓	✓
STP		✓	✓	✓	✓	✓	✓
SYNC	1.18.01	✓	✓	✓	✓	✓	✓
SYS		✓	✓	✓	✓	✓	✓
TANG	1.18.06	✓	✓	✓	X	✓	✓
TARC	1.18.06	✓	✓	✓	X	✓	✓
TLM		✓	✓	✓	✓	✓	✓
TMOV	1.18.01	✓	✓	✓	✓	✓	✓
TOV	1.18.04	✓	✓	✓	✓	✓	✓
TRG		✓	✓	✓	✓	✓	✓
TRJ		✓	✓	✓	✓	✓	✓
TROFF		✓	✓	✓	✓	✓	✓
TRON		✓	✓	✓	✓	✓	✓
UNLOCK		✓	✓	✓	✓	✓	✓
VECDEF		✓	✓	✓	✓	✓	✓
VECTOR		✓	✓	✓	✓	✓	✓
VEL LIMIT	 1.18.06	✓ ✓	✓ ✓	✓ ✓	✓ X	✓ ✓	✓ ✓
VER	1.17.05	✓	✓	✓	✓	✓	✓
WHILE	1.18.07	✓	✓	✓	✓	✓	✓

ACC

Set acceleration ramp

Format: ACC { rate }
Group: Velocity Profile
Units: units / second ^{2}

See also: DEC, STP, VEL, IVEL, FVEL, PPU

The ACC command sets the master acceleration used to ramp from lower to higher speeds. Issuing an ACC command with no argument will display the current setting. The default acceleration ramp is 20000 units / second ^{2}.

The ACC command can be also be used in expressions as follows:

```
DV1 = ACC + 100
ACC = DEC
```

Setting ACC to zero disables the acceleration ramp. In cases where the motor needs to speed up (such as with an FOV command), it will try to do so instantaneously.

The following figure explains the various ACC/DEC/STP usage:

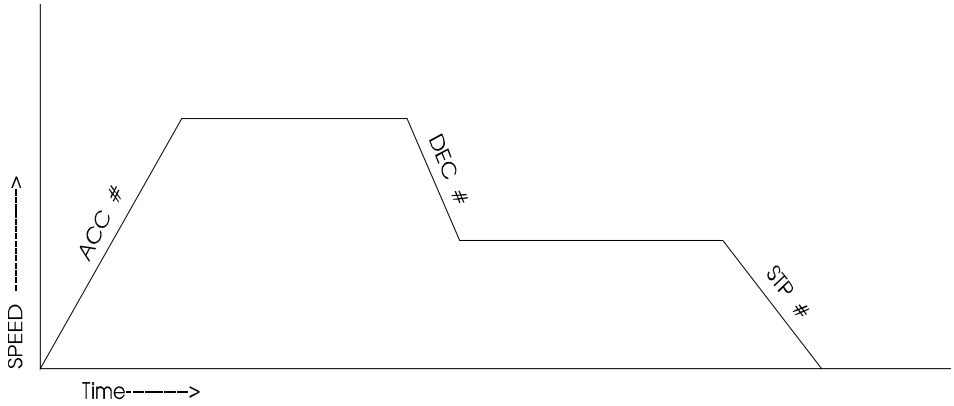


Figure 3.1 ACC/DEC/STP slopes

The following example sets up a acceleration ramp of 10000 units per second ^{2}:

Usage example:

```
10 ACC 10000
```

ADC

Analog Input

Format: ADC { index } command { data }
Group: Global Objects

See also: DAC, ENC, AXIS

This command is used along with a second command to control the optional analog input module. By default, the analog input module converts eight single-ended ±10 volt signals, using default positive inputs and treating the analog ground pin as the negative input for all channels. Optionally, the channels can be read as differential pairs by redirecting positive and negative input signals from any of the eight analog input pins.
Issuing an ADC command without an argument will display the current general setting for the ADC. Issuing an ADC command to an ADC channel without an argument will display the current setting for that ADC channel.

The following is a list of valid ADC command combinations:

`ADC MODE`	Select the firmware mode (Not available on the ACR2000 board)
`ADC MAX`	Set the number of ADCs (16 Bit ADC only)
`ADC SCALE`	Set the physical gain of PGA (16 Bit ADC only)
`ADC POS`	Select positive channel
`ADC NEG`	Select negative channel
`ADC GAIN`	Set analog input gain
`ADC OFFSET`	Set analog input offset
`ADC ON`	Enable ADC update
`ADC OFF`	Disable ADC update

The following table outlines parameters related to ADC operation:

ADC	Input	Gain	Offset
0	P6408	P6410	P6411
1	P6424	P6426	P6427
2	P6440	P6442	P6443
3	P6456	P6458	P6459
4	P6472	P6474	P6475
5	P6488	P6490	P6491
6	P6504	P6506	P6507
7	P6520	P6522	P6523

Table 3.1 ADC parameter cross-reference

ADC

Analog Input (continued)

Block Diagram:

The following block diagram outlines a single analog input channel:

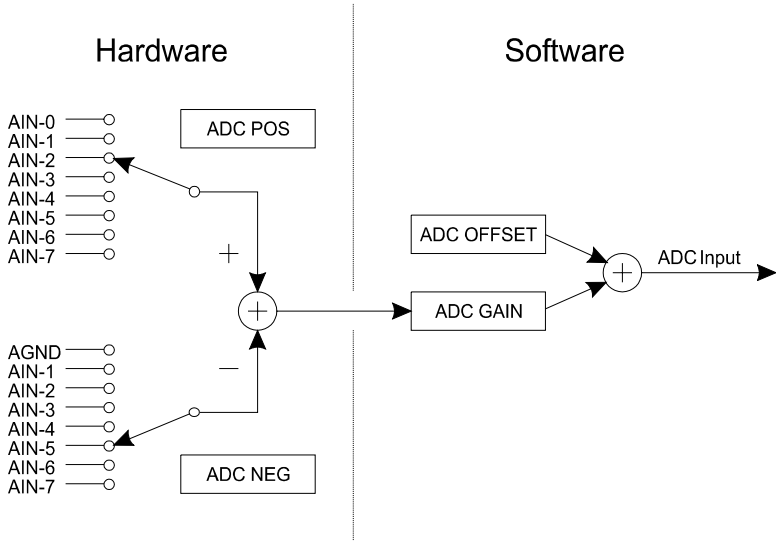


Figure 3.2 ADC input channel diagram

ADC MODE (Version 1.18 & Up)

Select the 12-Bit/16-Bit firmware mode

Format: ADC MODE { mode}
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the firmware mode for the 12 bit or 16 bit ADC module on the ACR1200/ACR1500/ACR8000/ACR8010 boards. Issuing an ADC MODE command with no argument will display the current mode. The default mode is for 12 bit ADC. The mode is set based on the type of ADC module installed, andis not interchangeable between modules. The ADC MODE can be saved using the ESAVE command.

Note:

The ACR2000 board only supports the on-board 12 Bit ADC option. 16 Bit ADC is not available on the ACR2000.

The following table shows the modes:

Mode	
0	STD 12 Bit ADC
1	16 Bit ADC

Table 3.2 ADC Mode

Usage example:

The following example sets mode to 16 bits ADC

```
ADC MODE 1
```

ADC MAX (16 BIT ADC ONLY) (Version 1.18 & Up)

Set the number of ADC Inputs

Format: ADC MAX { number }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the number of ADC inputs that will be sampled during the servo-interrupt period. Issuing an ADC MAX command with no argument will display the current number of ADC inputs selected. The default number is 8. This command is only for 16 bit ADC operation. . The ADC MAX can be saved using the ESAVE command.

NOTE: The 12 Bit ADC firmware always samples all 8 ADC inputs.

The following example sets the number of ADC inputs to 5 :

Usage example:

```
ADC MAX 5
```

ADC SCALE (16 BIT ADC ONLY) (Version 1.18 & Up)

Set the physical gain of PGA

Format: ADC index SCALE { scale }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

Unlike the 12 Bit ADC module, the 16 Bit ADC module has a built-in “Programmable Gain Amplifier” (PGA). This allows the user to scale the input signal to match four (4) ranges of input levels. This range can be selected individualy for each channel. This way, the entire range of 16 bits can be applied to read a +/- 1.25V, +/- 2.5V, +/- 5V, +/- 10V signal.

This command sets the physical gain of the PGA. Issuing an ADC SCALE command with no argument will display the current scale. The default gain is 1. This command is only for 16 bits ADC.

The following table shows the relationship between the gain and scale:

Scale	Gain
10	1
5	2
2.5	4
1.25	8

Table 3.3 ADC Scale

The following example sets the physical gain of ADC 1 to 2

Usage example:

```
ADC 1 SCALE 5
```

Usage example: **(ACR8020 only & version 1.18.07 &Up)**

```
ADC 12 SCALE 5
```

ADC POS

Select positive channel

Format: ADC index POS { channel }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the positive input for differential analog conversion. Issuing an ADC POS command with no argument will display the current setting. The default positive channel is equal to the ADC index number.

The following table shows the relationship between the "channel" and positive input: Reference appropriate hardware manual for pin-out information.

Channel	Pin Name
0	AIN0
1	AIN1
2	AIN2
3	AIN3
4	AIN4
5	AIN5
6	AIN6
7	AIN7

Table 3.4 ADC positive channels

The following example sets the positive input of ADC 4 to channel 2 :

Usage example:

```
ADC 4 POS 2
```

Usage example: **(ACR8020 only & version 1.18.07 &Up)**

```
ADC 12 POS 15
```

ADC NEG

Select negative channel

Format: ADC index NEG { channel }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the negative input for differential analog conversion. Issuing an ADC NEG command with no argument will display the current setting. The default negative channel is 0 for each conversion.

The following table shows the relationship between the "channel" and negative input. Note that channel 0 attaches to analog ground instead of input 0 like the positive channel assignment does. Reference appropriate hardware manual for pin-out information.

Channel	Pin Name
0	AGND
1	AIN1
2	AIN2
3	AIN3
4	AIN4
5	AIN5
6	AIN6
7	AIN7

Table 3.5 ADC negative channels

The following example sets the negative input of ADC 4 to channel 3 :

Usage example:

```
ADC 4 NEG 3
```

Usage example: **(ACR8020 only & version 1.18.07 &Up)**

```
ADC 12 NEG 14
```

Setup example for four (4) differential analog inputs:

ADC 0 POS 0 ADC 0 NEG 1	DIFFERENTIAL INPUT #1	P6408
ADC 1 POS 2 ADC 1 NEG 3	DIFFERENTIAL INPUT #2	P6424
ADC 2 POS 4 ADC 2 NEG 5	DIFFERENTIAL INPUT #3	P6440
ADC 3 POS 6 ADC 3 NEG 7	DIFFERENTIAL INPUT #4	P6456

ADC GAIN

Set analog input gain

Format: ADC index GAIN { gain }
Group: Global Objects
Units: volts / input unit

See also: ADC, DAC, ENC, AXIS

This command sets the software gain for analog conversion. Issuing an ADC GAIN command with no argument will display the current setting. The default ADC gain value is 10.0 volts / input unit.

When ADC updating is enabled, the readings from the analog input module are internally scaled to generate a base number of ±1.0 input units. This number is multiplied by the ADC GAIN setting and then the ADC OFFSET value is added. The result is stored in the ADC input parameter.

The first example sets the gain on ADC 2 to 9.985 volts = full input unit.
The second example will show 4095 = full scale input.

Usage example:

```
ADC 2 GAIN 9.985
ADC 2 GAIN 4095
```

Usage example: **(ACR8020 only & version 1.18.07 &Up)**

```
ADC 12 GAIN 5
```

ADC OFFSET

Set analog input offset

Format: ADC index OFFSET { offset }
Group: Global Objects
Units: volts

See also: ADC, DAC, ENC, AXIS

This command sets the software offset for analog conversion. Issuing an ADC OFFSET command with no argument will display the current setting. The default ADC offset value is 0.0 volts.

When ADC updating is enabled, the readings from the analog input module are internally scaled to generate a base number of ±1.0 input units. This number is multiplied by the ADC GAIN setting and then the ADC OFFSET value is added. The result is stored in the ADC input parameter.

The following example sets the offset on ADC 2 to 0.012 volts:

Usage example:

```
ADC 2 OFFSET 0.012
```

Usage example: **(ACR8020 only & version 1.18.07 &Up)**

```
ADC 12 OFFSET 0.05
```

ADC ON

Enable ADC update

Format: ADC ON
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command enables the update of the analog input module. Note that this command controls the update of all analog inputs and does not have an "index" operand like the other ADC commands.

The following example enables ADC updating:

Usage example:

```
ADC ON
```

ADC OFF

Disable ADC update

Format: ADC OFF
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command disables the update of the analog input module. Note that this command controls the update of all analog inputs and does not have an "index" operand like the other ADC commands.

The following example disables ADC updating:

Usage example:

```
ADC OFF
```

ADCX

Expansion board analog input

Format: ADCX
Group: Global Objects

See also: DAC, ENC, AXIS

This command will display the current setting of the ADC module on 16-axis expansion board.

Usage example:

```
ADCX
```

ADCX MODE (Version 1.18.07 & Up)

Select the 12-Bit/16-Bit firmware mode on expansion board

Format: ADCX MODE { mode}
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the firmware mode for the 12 bit or 16 bit ADC module on the ACR8020 16-axis expansion board. Issuing an ADCX MODE command with no argument will display the current mode. The default mode is for 12 bit ADC. The mode is set based on the type of ADC module installed, and is not interchangeable between modules. The ADCX MODE can be saved using the ESAVE command.

The following table shows the modes:

Mode	
0	STD 12 Bit ADC
1	16 Bit ADC

Table 3.2.1 ADCX Mode

The following example sets mode to 16 bits ADC on the expansion board.

Usage example:

```
ADCX MODE 1
```

ADCX MAX (16 BIT ADC ONLY) (Version 1.18.07 & Up)

Set the number of ADC Inputs on expansion board

Format: ADCX MAX { number }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the number of ADC inputs that will be sampled during the servo-interrupt period on ACR8020, 16-axis expansion board. Issuing an ADCX MAX command with no argument will display the current number of ADC inputs selected. The default number is 8. This command is only for 16 bit ADC operation. . The ADC MAX can be saved using the ESAVE command.

NOTE: The 12 Bit ADC firmware always samples all 8 ADC inputs.

The following example sets the number of ADC inputs to 5 on the expansion board:

Usage example:

```
ADCX MAX 5
```

ALM

Set stroke limit 'A'

Format: ALM { axis { value } } { axis { (high, low) } } ...
Group: Axis Limits
Units: units

See also: BLM, PPU

This command sets the command position (current position) limits monitored by the "A limit" flags. When the command position of a given axis is within these limits, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if all of its slaves are within their limits.

Issuing the ALM command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "high" and the negative limit to "low". The default for both is 0.0 for all axes.

The following is a table of 'A limit' flags:

MASTER	BIT
0	530
1	562
2	594
3	626
4	658
5	690
6	722
7	754

AXIS	BIT
0	770
1	802
2	834
3	866
4	898
5	930
6	962
7	994

Table 3.6 'A limit' flags

Usage example:

This example sets different positive and negative "A limits" for X, Y and Z axes.

```
ALM X(10,-10) Y(30,-20) Z(5,0)
```

ATTACH

Define attachments

Format: ATTACH { command }
Group: Operating System

See also: PROG, DETACH

This command is used along with a second command to define how programs, masters, axes, signals, and feedbacks are attached to one another. Issuing an ATTACH without the optional "command" will display the attachments to the current program or, if issued from the system level, all attachments to all programs.

The following is a list of valid ATTACH command combinations:

`ATTACH MASTER`	Attach master to program.
`ATTACH SLAVE`	Attach axis to master.
`ATTACH AXIS`	Attach signal and feedback to axis.

Block Diagram:

The following block diagram illustrates some sample attachments:

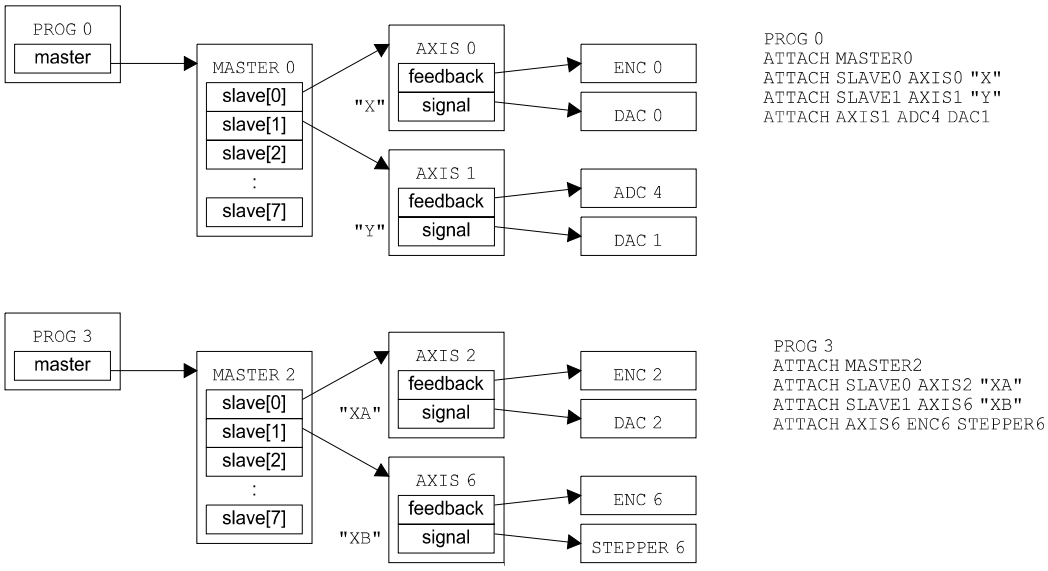


Figure 3.3 Sample attachments

ATTACH MASTER

Attach master to program

Format: ATTACH MASTER master
Group: Operating System
Units: none

See also: ATTACH, DETACH, PROG

This command attaches a master to the current program. Each master has eight internal slots that serve as attachment points for axes. This command must be issued from a program prompt. An error will be generated if the master is attached to another program.

Usage example:

This example attaches master 2 to program 0:

```
PROG0
ATTACH MASTER2
```

ATTACH SLAVE

Attach slave to axis

Format: ATTACH SLAVE slave AXIS axis "name"
Group: Operating System
Units: none

See also: ATTACH, DETACH

This command attaches an axis to the current master. The "slave" is an internal slot in the master that the axis is attached to. The "name" is a one to four character alpha string. An error will be generated if another axis is already attached to the slave or if the given axis is attached elsewhere.

Usage example:

This example attaches axes 3 and 4 to the current master as "X" and "Y":

```
ATTACH SLAVE0 AXIS3 "X"
ATTACH SLAVE1 AXIS4 "Y"
```

ATTACH AXIS

Attach axis to signal and feedback

Format: ATTACH AXIS { axis { position { signal { velocity } } } }
Group: Operating System
Units: none

See also: ATTACH, CONFIG, FBVEL

This command defines the attachment of position feedback and signal output for a given axis. If the ATTACH AXIS command is issued without the optional arguments, the current attachments for all axes are displayed.

The default position attachment is ENC "n", where "n" is equal to the index of the axis. The following are valid position feedback attachments:

`ENC` encoder	Quadrature encoder feedback
`ADC` adc	Analog position feedback
`STEPPER` stepper	Open loop stepper feedback

The default signal attachment is DAC "n", where "n" is equal to the index of the axis. The following are valid signal output attachments:

`DAC` dac	Analog voltage output
`STEPPER` stepper	Step and direction output
`CMT` commutator	Sinusoidal/Trapezoidal commutation output

The default velocity attachment is ENC "n", where "n" is equal to the index of the axis. The velocity of this item (derivative) is multiplied by the FBVEL setting and subtracted from the control signal. The following are valid velocity feedback attachments:

`ENC` encoder	Quadrature velocity feedback
`ADC` adc	Analog velocity feedback

Usage example:

This example attaches ENC 5 as position feedback, DAC 6 as signal output, and ADC 7 as velocity feedback on AXIS 4 :

```
ATTACH AXIS4 ENC5 DAC6 ADC7
```

AUT

Turn off block mode

Format: AUT { PROG number | ALL }
Group: Program Control

See also: BLK, STEP

This command turns off block mode for the currently selected program by clearing the program's "block control" bit. To continue normal operation after the AUT command, issue a STEP command or set the "step request" bit. The STEP command will detect that "block control" is no longer active and clear the "block mode" bit.

The AUT PROG command will turn off block mode for the corresponding program and the AUT ALL command will turn off block mode for all programs. These commands can be issued from anywhere in the system, including programs.

The following example turns off block mode:

Usage example:

```
AUT
```

AXIS

Direct axis access

Format: AXIS index command { data }
Group: Global Objects

See also: ENC, DAC, MASTER

This command allows direct access to an axis without having to use its name. The axis does not have to be attached to a master. In general, the "command" argument is any command or command pair that would normally be followed by an axis name and data. These commands include those from the axis limits, feedback control, servo control, and setpoint control groups.

Two other direct axis commands unique to this access mode are:

`AXIS ON`	Enable servo loop
`AXIS OFF`	Disable servo loop

These commands turn on and off the servo loop associated with an axis without having to use the bit flags designated for that purpose. Turning off unnecessary servo loops will reduce CPU load and improve system performance.

The following example sets the proportional gain on AXIS 3 to 0.001, jogs AXIS 2 to an absolute jog position of 2.5 units, and disables the AXIS 7 servo loop:

Usage example:

```
AXIS3 PGAIN 0.001
AXIS2 JOG ABS 2.5
AXIS7 OFF
```

BKL

Set backlash compensation

Format: BKL { axis { value } } { axis { value } } ...
Group: Setpoint Control
Units: units

See also: BSC, CAM, GEAR, HDW, JOG

This command sets or displays the backlash compensation of an axis. Backlash is primarily used to compensate for error introduced by hysteresis in mechanical gearboxes. Backlash is added to the secondary setpoint when the primary setpoint moves in the positive direction. If the primary setpoint is not changing, the backlash stays in its previous state. The backlash offset is used during the summation of the secondary setpoint.

This compensation is added in one servo update, therefore a large BKL offset will result in the motor "jerking" a little but the motion at the load should be smooth. For the same reason this feature might not be usable in a stepper application if the stepper translator cannot handle pulses too close together.

Issuing a BKL command to an axis without an argument will display the current setting for that axis. The default backlash is 0.0 for all axes.

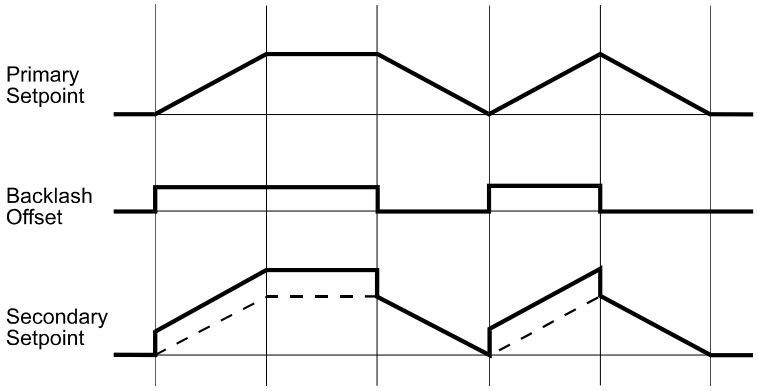


Figure 3.4 Backlash compensation

Note: The primary setpoint is the summation of the current position and the total cam, gear, and jog offsets. The secondary setpoint is the summation of the primary setpoint and the total ballscrew and backlash offsets. The secondary setpoint is the one that is actually used by the servo loop.

Usage example:

This example sets backlash compensation for the X axis to 0.0025 units.

```
BKL X0.0025
```

BLK

Turn on block mode

Format: BLK { PROG number | ALL }
Group: Program Control

See also: AUT, STEP

This command turns on block mode for the currently selected program by setting the "block control" bit. If there is no master attached, the "block mode" bit is set as soon as the "block control" bit is detected. Otherwise, the program will feedhold and then set the "block mode" when the master "in feedhold" is detected.

While in block mode, the program will use the DEC setting as the STP for all moves. This prevents consecutive moves with STP 0 from coming to abrupt stops. When the program is taken out of block mode with the AUT command, moves operate normally.

Master cycle start requests are ignored until after the first STEP is issued in block mode.

The BLK PROG command will turn on block mode for the corresponding program and the BLK ALL command will turn on block mode for all programs. These commands can be issued from anywhere in the system, including programs.

The following example turns on block mode:

Usage example:

```
BLK
```

BLM

Set stroke limit 'B'

Format: BLM { axis { value } } { axis { (high, low) } } ...
Group: Axis Limits
Units: units

See also: ALM, PPU

This command sets the command position (current Position) limits monitored by the "not B limit" flags. When the command position of a given axis is outside of these limits, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if any of its slaves are outside of their limits.

Issuing the BLM command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "high" and the negative limit to "low". The default for both is 0.0 for all axes.

The following is a table of 'Not B limit' flags:

MASTER	BIT
0	531
1	563
2	595
3	627
4	659
5	691
6	723
7	755

AXIS	BIT
0	771
1	803
2	835
3	867
4	899
5	931
6	963
7	995

Table 3.7 'Not B limit' flags

Usage example:

This example sets the B limits to ±10 units for the X, Y and Z axes. If the axes are ever all within their B limits at the same time, the appropriate master flag will clear.

```
BLM X10 Y10 Z10
```

BRESET

Disable battery backup

Format: BRESET
Group: Nonvolatile

See also: ELOAD, ESAVE, ERASE, PBOOT

ACR8000:
This command disables the battery backup the next time power is removed from the board. This allows ACR8000 boards to be stored on the shelf without needlessly draining power from the battery. The next time power is applied to the board, after shutting down with BRESET in effect, the battery will return to normal and will hold programs during consecutive power sequences.

Note: Once this command is issued, there is no way to return the battery to normal operation without removing and then restoring power. Stored programs will be lost.

ACR1200ACR2000/ACR8010:
This command sets the battery backup memory to its default state the next time power is removed from the board or the board is reset. This allows the ACR1200 / ACR2000 / ACR8010 battery backed up memory to be cleared to default without physically removing the battery jumpers on the ACR1200 board, the ACR8010 board or the ACR2000 ACRCOMM board. Reference the ACR1200/ACR2000/ACR8010 Hardware Manual (ACR2000 ACRCOMM section) for jumper settings to allow the boards to be stored on the shelf without needlessly draining power from the battery. The next time power is applied to the board, after shutting down or after resetting the board with BRESET in effect, the battery backed up memory will return to normal and will hold programs during consecutive power sequences.

If valid program data has been stored into the Flash, using the FLASH SAVE or FLASH IMAGE commands, this will overwrite the default conditions of the battery backed up memory when using BRESET. If the default memory conditions are required, a FLASH ERASE should be performed before the BRESET command.

Note: Once this command is issued, there is no way to return the battery backed up memory to normal operation without removing and then restoring power or resetting the board. Stored programs will be lost.

ACR1500:

This command performs no function on the ACR1500 board.

Usage example:

```
BRESET
```

BSC

Ballscrew compensation

Format: BSC command { axis { data } } { axis { data } } ...
Group: Setpoint Control

See also: CAM, BKL, GEAR, HDW, JOG

This command is used along with a second command to initialize and control ballscrew compensation for an axis. Ballscrew compensation is primarily used to compensate for nonlinear position error introduced by mechanical ballscrews. Ballscrew commands are identical to cam commands. Both ballscrews and cams can be active at the same time, each with different settings and offset tables.

The following is a list of valid ballscrew command combinations. See the corresponding cam command description for details.

`BSC DIM`	Allocate ballscrew segments
`BSC SEG`	Define ballscrew segment
`BSC SRC`	Redefine ballscrew source
`BSC ON`	Enable ballscrew output
`BSC OFF`	Disable ballscrew output
`BSC SCALE`	Set ballscrew output scaling
`BSC OFFSET`	Set ballscrew output offset
`BSC FLZ`	Set ballscrew input offset
`BSC SHIFT`	Set incremental ballscrew shift
`BSC RES`	Transfer ballscrew offset

The main difference between ballscrew and electronic cam is that the default source for a ballscrew points to the primary setpoint, therefore the BSC SRC command is normally not required. The primary setpoint is used so that the ballscrew offset is not fed into the calculation of the ballscrew index, causing an unstable condition.

Note: The primary setpoint is the summation of the current position and the total cam, gear, and jog offsets. The secondary setpoint is the summation of the primary setpoint and the total ballscrew and backlash offsets. The secondary setpoint is the one that is actually used by the servo loop.

Ballscrew compensation (continued)

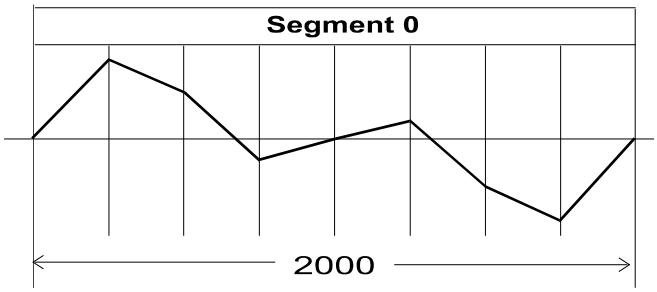


Figure 3.5 Sample ballscrew table

The following example enables the X axis to use the above ballscrew table:

Usage example:

```
DIM LA(2)

DIM LA0(9)
LA0(00)=0
LA0(01)=853
LA0(02)=500
LA0(03)=-146
LA0(04)=0
LA0(05)=146
LA0(06)=-500
LA0(07)=-853
LA0(08)=0

BSC DIM X1
BSC SEG X(0,2000,LA0)
BSC ON X
```

CAM

Electronic cam

Format: CAM command { axis { data } } { axis { data } } ...
Group: Setpoint Control

See also: BKL, BSC, GEAR, HDW, JOG

This command is used along with a second command to control an electronic cam for an axis. An electronic cam is primarily used as a replacement for a mechanical cam. Ballscrew commands are identical to cam commands. Both ballscrews and cams can be active at the same time, each with different settings and offset tables.

The following is a list of valid cam command combinations:

`CAM DIM`	Allocate cam segments
`CAM SEG`	Define cam segment
`CAM SRC`	Redefine cam source
`CAM ON`	Enable cam output
`CAM OFF`	Disable cam output
`CAM SCALE`	Set cam output scaling
`CAM OFFSET`	Set cam output offset
`CAM FLZ`	Set cam input offset
`CAM SHIFT`	Set incremental cam shift
`CAM RES`	Transfer cam offset
`CAM ON TRG`	Enable CAM ON from external trigger

Cam uses an arbitrary encoder position to generate an index into a table of offset values. If this index falls between two table entries, the cam offset is linearly interpolated between the entries. This offset is then scaled, shifted by the output offset, and then multiplied by the PPU for the given axis.

A cam table can be composed of more than one segment with each segment having different distances between table entries. The data for each segment of the table resides in separate longint arrays, possibly of different sizes. This allows some parts of the table to be defined coarsely and others to be defined in more detail.

The table index automatically tracks which segment it is in and where it is within that segment. It also wraps around if it goes off either end of the table. The wraparound point is determined by the total length of the table which is equal to the summation of the individual segment lengths.

Note: The primary setpoint is the summation of the current position and the total cam, gear, and jog offsets. The secondary setpoint is the summation of the primary setpoint and the total ballscrew and backlash offsets. The secondary setpoint is the one that is actually used by the servo loop.

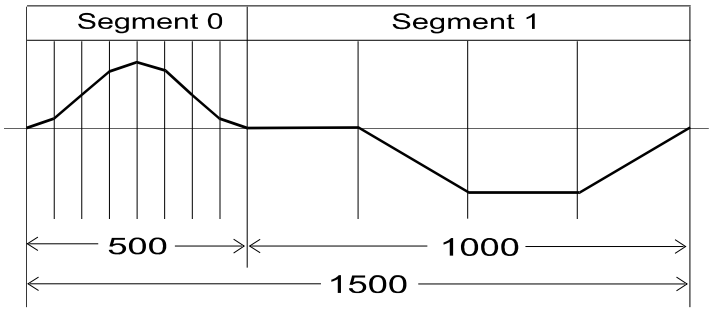


Figure 3.6 Sample cam table

The following example enables the X axis to use the above cam table with encoder number 4 as the input source:

Usage example:

```
DIM LA(2)

DIM LA0(9)
LA0(00)=0
LA0(01)=73
LA0(02)=250
LA0(03)=427
LA0(04)=500
LA0(05)=427
LA0(06)=250
LA0(07)=73
LA0(08)=0

DIM LA1(5)
LA1(00)=0
LA1(01)=0
LA1(02)=-500
LA1(03)=-500
LA1(04)=0

CAM DIM X2
CAM SEG X(0,500,LA0)
CAM SEG X(1,1000,LA1)
CAM SRC X4
CAM ON X
```

Note:

The CAM SRC command must be issued AFTER the cam segments have been defined. Improper operation may result from designating the CAM SRC first.

Issuing just the CAM command will display the current setting of a cam and can be used even if the cam is currently active. The example below shows the list

Usage example:

```
P00>CAM X
CAM FLZ X0
CAM OFFSET X0
CAM SCALE X1
CAM DIM X4
CAM SEG X (0, 2000, LA1)
CAM SEG X (1, 2000, LA3)
CAM SEG X (2, 2000, LA1)
CAM SEG X (3, 2000, LA0)
CAM SHIFT X0
CAM SRC X P12802
CAM  ON X
```

CAM Cycles

Axis parameter " CAM Cycles " can be set to run so many CAM cycles. Says this parameter is set to 3, then the CAM will run for 3 times and then automatically turn itself off. The defalut value is zero which means that the CAM will run forever unless the user turns it off.

Example 1

```
P12400 = 3
CAM ON X TRG (0,0)  :REM The CAM  will run 3 times
:
CAM ON X TRG (0,0)  :REM The CAM  will run 3 times
```

The cam source is automatically reset when ussing the triggerd CAM

Example 2

```
P12400 = 3
CAM SRC X RES
CAM ON X  :REM The CAM  will 3 times
CAM SRC X RES
CAM ON X :REM The CAM  will 3 times
```

The cam source is explicitly reset and the source should not be moving before the cam is trun on otherwise the CAM will not begin from the start.

CAM Velocity Smooth

Axis Parameter "CAM Velocity Smooth" is used to smooth out the CAM velocity that is used for the feed forward control. The Default value is 10, which means that the velocity is averaged on 10 samples to take away the jitter in the velocity term. The user can change this value to suite his application, however it should be changed before turning the CAM ON.

CAM CLEAR

Clear the CAM setting

Format: **CAM CLEAR {axis}**
Group: set point control
See also: CAM

This command is used to clear the current setting of a cam. This command will turn off the cam and initialize all the cam variables to the default values. It can be used even if the cam is currently active.

NOTE: The memory allocated to the CAM DIM command will still be there and so will be the number of segments and their respective lengths. The cam can not be re-dimensioned by this command. If needed one has to use CLEAR ALL command to clear all the memory.

Usage example:

```
CAM CLEAR Y
```

CAM DIM

Allocate cam segments

Format: CAM DIM { axis segments } { axis segments } ...
Group: Setpoint Control

See also: CAM, BKL, BSC, GEAR, HDW, JOG, DIM, CLEAR

This command allocates working space for a cam. The cam must be dimensioned before it can be initialized. This is in addition to the dimensioning done for the actual arrays attached to the cam segments. Newly dimensioned cams have no source defined for them, ballscrews point to the primary setpoint by default.

A cam can be composed of more than one segment with each segment having different distances between table entries. This allows some parts of the table to be defined coarsely and others to be defined in more detail.

The memory allocated by the CAM DIM command is a base of 52 bytes of working space plus an additional 24 bytes per defined segment.

Once a cam has been allocated, it can not be redimensioned to a different size without first doing a CLEAR to erase all dimensioning. This will also deallocate any dimensioned user variables or cams. Do not allocate any more segments than are required by the application.

The following example allocates two cam segments for the X axis and a single segment for the Y axis:

Usage example:

```
CAM DIM X2 Y1
```

CAM SEG

Define cam segment

Format: CAM SEG { axis (segment , length , array_name) } ...
Group: Setpoint Control

Units:

segment	= none
length	= input units
array_name	= none

See also: CAM, BKL, BSC, GEAR, HDW, JOG, DIM, CLEAR

This command defines the segments that were allocated with the CAM DIM command. The "segment" is a number from 0 to segments-1 and indicates which segment is being defined. The "length" parameter defines the total length of the given segment. The "array_name" is the name of the longint array where the data points are to be stored.
An error will occur if the cam has not been allocated with the CAM DIM command.

A cam can be composed of more than one segment with each segment having different distances between table entries. This allows some parts of the table to be defined coarsely and others to be defined in more detail.

The following internal formulas are modified by the CAM SEG information:

distance between entries	= segment length / (number of table entries - 1)
total length of the cam	= sum of segment lengths

Note that this information can be altered while the cam is enabled, allowing the replacement of segments or the changing segment lengths on the fly.

The following example defines the segment 1 of the X axis cam as being 10000 units long and pointing to longint array LA0 for its data:

Usage example:

```
CAM SEG X(1,10000,LA0)
```

Issuing just CAM SEG command will display cam segment data.

Usage example:

```
P00>CAM SEG X
Seg_0 (0,  100,  500,  500)
Seg_1 (500,  1500,  2000,  3000)
Seg_2 (3000,  2500,  1000,  500)
Seg_3 (500,  500,  100,  0)
```

CAM SRC

Redefine cam source

Format: CAM SRC axis sourcedef { axis sourcedef } ...
Group: Setpoint Control
Units: none

See also: SRC

This command specifies the source for the input of a cam. See the SRC command for the definition of the "sourcedef" argument.

This command sets a pointer to a memory area that is used to generate an index into the cam table. Cams do not have a default source assigned to them, ballscrews point to the primary setpoint by default. An error will occur if the cam has not been allocated with the CAM DIM command.

The following example sets the source of the X axis to encoder 3 and the source of the Y axis to the current position of AXIS1 (note that the parameter P12544 is not enclosed in parentheses) :

Usage example:

```
CAM SRC X3 Y P12544
```

CAM SRC RES

Reset the cam source

Format: **CAM SRC {axis} RES**
Group: Setpoint Control
See also: SRC

This command resets the source the for the input of a cam. Usually it will be used when the cam is off and the source needs to be reset to a certain value.

Usage example:

```
CAM SRC X RES             :REM Reset source of X to zero
CAM SRC X RES 100         :REM Reset source to 100
```

CAM ON

Enable cam output

Format: CAM ON { axis } { axis } ...
Group: Setpoint Control

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command enables cam output for the designated axes. An error will be returned if the cam has not been allocated with the CAM DIM command.

NOTE: Once CAM is enabled, it will stay enabled unless CAM Parameter "CAM CYCLES" is set to a value other than zero.

The following example enables the X, Y, and Z axis cams:

Usage example:

```
CAM ON X Y Z
```

CAM OFF

Disable cam output

Format: CAM OFF { axis } { axis } ...
Group: Setpoint Control

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command disables cam output for the designated axes. An error will be returned if the cam has not been allocated with the CAM DIM command.

The following example disables the X and Y axis cams:

Usage example:

```
CAM OFF X Y
```

CAM SCALE

Set cam output scaling

Format: CAM SCALE { axis { scale } } { axis { scale } } ...
Group: Setpoint Control
Units: none

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command sets or displays the cam output scaling of an axis. After the cam table and index are used to interpolate an initial offset value, the value is multiplied by the cam output scaling factor and then shifted by the cam output offset. This number is then multiplied by the PPU of the given axis.

Issuing a CAM SCALE command to an axis without an argument will display the current setting for that axis. An error will be returned if the cam has not been allocated with the CAM DIM command. The default cam output scaling is 1.0 for all axes.

The following example scales the X axis cam offset by 50 percent:

Usage example:

```
CAM SCALE X0.5
```

CAM OFFSET

Set cam output offset

Format: CAM OFFSET { axis { scale } } { axis { scale } } ...
Group: Setpoint Control
Units: output units

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command sets or displays the cam output offset of an axis. After the cam table and index are used to interpolate an initial offset value, the value is multiplied by the cam output scaling factor and then shifted by the cam output offset. This number is then multiplied by the PPU of the given axis.

Issuing a CAM OFFSET command to an axis without an argument will display the current setting for that axis. An error will be returned if the cam has not been allocated with the CAM DIM command. The default cam output offset is 0.0 for all axes.

The following example shifts the X axis cam table output 500 units:

Usage example:

```
CAM OFFSET X500
```

CAM FLZ

Set cam input offset

Format: CAM FLZ { axis { offset } } { axis { offset } } ...
Group: Setpoint Control
Units: input units

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command sets or displays the cam input offset of an axis. The cam input offset is added to the cam table index before it is used to calculate the actual table index. This is used to shift the zero of the table to the location of the input offset.

Issuing a CAM FLZ command to an axis without an argument will display the current setting for that axis. An error will be returned if the cam has not been allocated with the CAM DIM command. The default cam input offset is 0.0 for all axes.

The following example shifts the X axis cam table index by 250 units:

Usage example:

```
CAM FLZ X250
```

CAM SHIFT

Set incremental cam shift

Format: CAM SHIFT { axis { offset } } { axis { offset } } ...
Group: Setpoint Control
Units: units

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command sets the incremental cam shift. The first entry of one cam segment is normally equal to the last entry of the previous segment. In cases where this is not true, the cam is considered to be incremental. The starting "shift" for all cams is 0.0. Issuing a CAM SHIFT with no argument will display the current reading.

Whenever an incremental cam crosses a segment boundary, the difference between the two entries is used to adjust the cam shift. The cam shift is added to the interpolated offset to generate the actual cam offset. If the total of all segment boundary shifts is not equal to zero, the overall pattern will be offset by that amount each cycle. Crossing cam segment boundaries backwards will also adjust the cam shift.

The following example clears the X axis cam shift:

Usage example:

```
CAM SHIFT X0
```

CAM RES

Transfer cam offset

Format: CAM RES { axis { offset } } { axis { offset } } ...
Group: Setpoint Control
Units: units

See also: CAM, BKL, BSC, GEAR, HDW, JOG

This command either clears or preloads the cam offset of a given axis and adds the difference to the current position. This command will also clear out any cam shift that may have been built up by an incremental cam. The default "offset" argument is zero. The current position and cam offset are adjusted according to the following formula:

current_position = current_position + cam_offset - offset
cam_offset = offset

When a cam is turned off, the offset remains in the cam offset parameter. The CAM RES command can be used to transfer the offset into the current position where it can be used as part of a normal move.

The following example transfers the X axis cam offset into the current position:

Usage example:

```
CAM RES X
```

CAM ON TRG (Version 1.18.04 & Up)

Enable external source trigger CAM

Format: CAM ON {axis} TRG(mode,capture_register)
Group: Setpoint Control

See also: CAM, HDW, BSC, BKL, GEAR, JOG

This command is not valid for the ACR8000.

This command arms the loaded CAM to begin when an externally sourced trigger occurs. The latency error is 1 microsecond. The mode parameter and hardware capture register information for the CAM ON TRG is the same as those used in the INTCAP command.

NOTE: It is recommended that the CAM source should be attached before the source starts to move

The following example enables or starts the Y axis cam when triggered by rising primary marker of encoder 0.

Usage example:

```
CAM SRC Y 0
CAM ON Y TRG(0,0)
```

If the CAM needs to be turned off and armed again then issue the following commands

```
CAM OFF Y
CAM RES Y
CAM ON Y TRG(0,0)
```

CAM ON TRGP (Version 1.18.06 Update 09)

Enable external trigger CAM

Format: CAM ON {axis} TRG(mode,capture_register)
Group: Setpoint Control

See also: CAM, HDW, BSC, BKL, GEAR, JOG

This command is not valid for the ACR8000.

This command is same as the CAM ON TRG, except that the cam source can be any P parameter. In this case the capture register value is not used since the cam source value is different than the capture register value. This is less precise than the CAM ON TRG and the worse case error can be one servo period.

The following example enables or starts the Y axis cam when triggered by rising primary marker of encoder 0.

Usage example:

```
CAM SRC Y P12288
CAM ON Y TRGP(0,0)
```

If the CAM needs to be turned off and armed again then issue the following commands

```
CAM OFF Y
CAM RES Y
CAM ON Y TRGP(0,0)
```

CIRCCW (Version 1.18 04 Upd 1 & Up)

2-Dimensional Counter Clockwise Circle

Format: **CIRCCW {axis (target, center) axis(target, center)}**
Group: Interpolation
See also: SINE, CIRCW

This command generates a circular profile on the plane defined by the two selected axes. The command can be used to generate any counter clockwise arc between 0 to 360 degree.

target	position at the end of the move (in units)
center	center of the circle to by drawn (in units)

The following formula is used to calculate the start point of the arc. The profiler will always start from this point and end at the target point. If the current axis position does not match this start point then the axis will jump to the start point.

theta = start angle of arc
radius = radius of the arc = target - center

xstart = xcenter + radius * cos(theta)
ystart = ycenter + radius * sin(theta)

The start point of the arc is derived from the above calculations. If the current position is not equal to the calculated start point, the arc must be proceeded with a move to (xstart, ystart) or the axes will try to jump immediately to that point.

Usage example:

```
CIRCCW X ((LV1),(LV2) ) Y ((LV3),(LV4) )        Variable    target
                                                and center.
CIRCCW X (59.078, -59) Y (-75.576, -100)        Absolute    target
                                                and center.
CIRCCW X/(110.23, 134) Y (-152.309, -80)        X-axis         has
                                                incremental target
                                                and center
```

CIRCW (Version 1.18 04 Upd 1 & Up)

2-Dimensional Clockwise Circle

Format: **CIRCCW {axis (target, center) axis(target, center)}**
Group: Interpolation
See also: SINE, CIRCCW

See the CIRCCW command for details, the only difference is that this draws clockwise arc instead of counter clockwise arcs.

Usage example:

```
CIRCW X ((LV1),(LV2) ) Y ((LV3),LV4) )          Variable target and
                                                center
CIRCW X (59.078, -59) Y (-75.576, -100)         Absolute target and
                                                center
CIRCW X/(110.23, 134) Y (-152.309, -80)         X-axis has
                                                incremental target
                                                and center
```

CLEAR

Clear memory allocation

System Level Formats:

CLEAR
CLEAR FIFO
CLEAR COM1
CLEAR COM2

Program Level Format:

CLEAR

Group: Memory Control

See also: DIM, MEM

This command will free memory that was dimensioned for programs, variables, and arrays and data logging. This command behaves differently depending on whether the communication port is at the system or program level.

From the system level, the CLEAR command will free the memory allocated to all programs. The programs must be empty for this to work. If the programs are not empty, an error will be given. After clearing the programs, the DIM command must be used to allocate memory for the programs as required.

Stream buffers may also be returned to their default 256 byte storage area using the CLEAR command from the system level. After the stream is redimensioned and ready for use, the appropriate “Stream Redimensioned” flag will be set.

From the program level, or within a running program, the CLEAR command frees the memory allocated to local variables and arrays.

Usage example:

```
SYS
HALT ALL
NEW ALL
DETACH ALL
CLEAR
```

CLOSE

Close a device

Format: CLOSE #device
Group: Character I/O

See also: PRINT, INPUT, OPEN

This command closes a device. The valid range for "device" is 0 to 3. Each program has it's own device #0 which is used as its default device. Devices #1 through #3 are board-wide system resources that can be closed from within any program or from any system or program prompt.

When a device is opened, the operating system attached to that device enters an idle state, allowing incoming characters to be used by a program instead of being interpreted as commands. When the device is closed, the device will enter its auto-detect mode as if it were starting from power-up.

Usage example:

```
CLOSE #1
```

CLR

Clear a bit flag

Format: CLR index
Group: Logic Function

See also: SET, INH, BIT

This command clears the specified bit flag. This flag can either be a physical output or an internal bit flag.

The following example will clear output 32:

Usage example:

```
10 CLR 32
```

CMT (Version 1.18 & Up)

Commutation

Format: CMT index command {data} {command {data}}…
Group: Global Objects

See also: ATTACH,DAC,ENC,AXIS

The commutation is available on ACR1200, ACR1500, ACR8010 ACR2000 and ACR8020 version 1.18 and above only. Commutation is not available on the ACR8000 Board.

The commutator takes the output of the servo loop as its input and performs sinusoidal/trapezoidal computation according to the shaft position. Each commutator (CMT) object uses two dac outputs to generate sinusoidal or trapezoidal signals to command “phased sine” input type servo amplifiers. Additionally, the commutator may use an extra encoder input to read hall effect channels for each moter. Therefore, the ACR8010 can control a maximum of four axis, if they are all being commutated. The ACR1500 and ACR2000 can do a maximum of two (2) axis. This is because the ACR8010 and the ACR2000 have a maximum of eight (8) and four (4) dacs, respectively. The ACR1200, with a maximum of two (2) dac outputs, can be configured for a single axis of commutation.

By default each commutator starts up in trapezoidal mode and switches over to sinusoidal mode at the occurance of the first marker pulse of the feedback encoder. The user can choose to force the system to stay in the trapezoidal mode using the CMT MODE command. The user can also choose to start the commutator without hall signals. In Hall-less start up mode the moter shaft will jerk . Once the shaft is locked to a known position the commutator will switch over to sinusoidal mode.

The following is a list of valid CMT command combinations:

`CMT ON`	Turn on commutator
`CMT OFF`	Turn off commutator
`CMT ENC ENC`	Set source of commutation position feedback and hall signal
`CMT DAC DAC`	Set sources of output signals
`CMT MODE`	Set commutation mode
`CMT ANG`	Set phase difference between the two CMT output signals
`CMT SHIFT`	Set the phase offset
`CMT PPR`	Set the encoder line per revolution of the motor
`CMT ERPMR`	Set Electrical revolution per mechanical revolution or poles_pair.
`CMT MAX RPM`	Set maximum speed
`CMT MAX AMP`	Set maximum peak current
`CMT HSEEK CAP`	Set up parameter ERPMR and SHIFT automatically.
`CMT LOCK AMP`	Set current amplitude for hall-less start up
`CMT LOCK RANGE`	Set lock position accuracy
`CMT LOCK COUNT`	Set lock position accuracy

Commutation (continued)

Issuing a CMT command with an index, but without an additional command, will display the current setting of the commutator.

The example assumes CMT0 as output of AXIS0 (X) and ENC0 as position feedback on AXIS0 as follows:

ATTACH AXIS0 ENC0 CMT0 ENC0

Usage example1:

```
10 CMT0 ENC0 ENC1
20 CMT0 MODE 8
30 CMT0 ANG 120
40 CMT0 DAC0 DAC1
50 CMT0 SHIFT 100
60 CMT0 PPR 1024
70 CMT0 ERPMR 2
80 CMT0 MAX RPM 4500
90 CMT0 MAX AMP 10
100 CMT0 ON
```

Usage example2:

```
10 CMT0 MODE 1
20 CMT0 ON
30 CMT0 HSEEK 0.5 CAP2
```

Usage example3:

```
10 CMT0 DAC0 DAC1
20 CMT0 ENC0 ENC0
20 CMT0 PPR 1024
30 CMT0 MODE 2
40 CMT0 MAX RPM 4500
50 P16406 = 2
60 CMT0 MAX AMP 5
70 CMT0 ERPMR 2
80 CMT0 LOCK COUNT 200
90 CMT0 LOCK RANGE 5
100 CMT0 LOCK AMP .5
```

Commutation (continued)

Related commutation Flags:

Flag Parameter	4208	4209	4210	4211	4212	4213	4214	4215

CMT Flags	Bit Index	CMT Number							
		0	1	2	3	4	5	6	7
CMT Commutator ON	0	3584	3616	3648	3680	3712	3744	3776	3808
CMT Sinusoidal ON	1	3585	3617	3649	3681	3713	3745	3777	3809
CMT Motor Overspeed	2	3586	3618	3650	3682	3714	3746	3778	3810
CMT Encoder Fault	3	3587	3619	3651	3683	3715	3747	3779	3811
CMT EncCheck Disable	4	3588	3620	3652	3684	3716	3748	3780	3812
CMT Following Error	5	3589	3621	3653	3685	3717	3749	3781	3813
Reserved	6	3590	3622	3654	3686	3718	3750	3782	3814
Reserved	7	3591	3623	3655	3687	3719	3751	3783	3815
Spare	8	3592	3624	3656	3688	3720	3752	3784	3816
Spare	9	3593	3625	3657	3689	3721	3753	3785	3817
Spare	10	3594	3626	3658	3690	3722	3754	3786	3818
Spare	11	3595	3627	3659	3691	3723	3755	3787	3819
Spare	12	3596	3628	3660	3692	3724	3756	3788	3820
Spare	13	3597	3629	3661	3693	3725	3757	3789	3821
Spare	14	3598	3630	3662	3694	3726	3758	3790	3822
Spare	15	3599	3631	3663	3695	3727	3759	3791	3823
CMT Pseek Enable	16	3600	3632	3664	3696	3728	3760	3792	3824
Spare	17	3601	3633	3665	3697	3729	3761	3793	3825
Spare	18	3602	3634	3666	3698	3730	3762	3794	3826
Spare	19	3603	3635	3667	3699	3731	3763	3795	3827
Spare	20	3604	3636	3668	3700	3732	3764	3796	3828
Spare	21	3605	3637	3669	3701	3733	3765	3797	3829
Spare	22	3606	3638	3670	3702	3734	3766	3798	3830
Spare	23	3607	3639	3671	3703	3735	3767	3799	3831
Spare	24	3608	3640	3672	3704	3736	3768	3800	3832
Spare	25	3609	3641	3673	3705	3737	3769	3801	3833
Spare	26	3610	3642	3674	3706	3738	3770	3802	3834
Spare	27	3611	3643	3675	3707	3739	3771	3803	3835
Spare	28	3612	3644	3676	3708	3740	3772	3804	3836
Spare	29	3613	3645	3677	3709	3741	3773	3805	3837
Spare	30	3614	3646	3678	3710	3742	3774	3806	3838
Spare	31	3615	3647	3679	3711	3743	3775	3807	3839

Commutation (continued)

CMT Commutator ON	r	This flag is set when the commutator is ON.
CMT Sinusoidal ON	r	This flag is set when the commutator is in sinusoidal mode.
CMT Motor Overspeed	r	This flag is set if overspeed is detected. The commutator will be turned off if this bit is set.
CMT Encoder Fault	r	This flag is set if an encoder fault is detected . The commutator will be turned off if this bit is set and the *CMT ENCCHECK DISABLE flag* is reset.
CMT EncCheck Disable	r/w	When this flag is reset, the commutator will be turned off if an encoder fault is detected. When this flag is set, the commutator won't be turned off even though an encoder fault is detected
CMT Following Error	r	This flag is set if following error exceeds MaxFollowingERR. The commutator will be turned off if this be is set.
CMT Pseek Enable	r/w	If this flag is set and the commutator is turned on at mode 2, at the ccurance of the first marker pulse of the feedback encoder, parameter PhaseMarkerOffset will be set by firmware and this flag will be cleared.

r = read, w = write

Commutation (continued)

Related commutation parameters:

CMT Parameters		CMT Number							
		0	1	2	3	4	5	6	7
FeedBackEncoder	LONG	16384	16640	16896	17152	17408	17664	17920	18176
AngleBetweenPhases	LONG	16385	16641	16897	17153	17409	17665	17921	18177
EncoderShaftPosition	LONG	16386	16642	16898	17154	17410	17666	17922	18178
PhaseADacChannel	LONG	16387	16643	16899	17155	17411	17667	17923	18179
PhaseBDacChannel	LONG	16388	16644	16900	17156	17412	17668	17924	18180
PulsePerRevolution	LONG	16389	16645	16901	17157	17413	17669	17925	18181
PhaseAADCChannel	LONG	16390	16646	16902	17158	17414	17670	17926	18182
PhaseBADCChannel	LONG	16391	16647	16903	17159	17415	17671	17927	18183
PhaseMarkerOffset	LONG	16392	16648	16904	17160	17416	17672	17928	18184
ElecRevPerMechRev	LONG	16393	16649	16905	17161	17417	17673	17929	18185
HallEffectChannel	LONG	16394	16650	16906	17162	17418	17674	17930	18186
PhaseLockCount	LONG	16395	16651	16907	17163	17419	17675	17931	18187
MaxEncDelta	LONG	16396	16652	16908	17164	17420	17676	17932	18188
Reserved	LONG	16397	16653	16909	17165	17421	17677	17933	18189
MaxFollowingErr	LONG	16398	16654	16910	17166	17422	17678	17934	18190
CommutationRegion	LONG	16399	16655	16911	17167	17423	17679	17935	18191
CommandSignal	FP32	16400	16656	16912	17168	17424	17680	17936	18192
Reserved	FP32	16401	16657	16913	17169	17425	17681	17937	18193
SineIndexPerEncCount	FP32	16402	16658	16914	17170	17426	17682	17938	18194
Reserved	FP32	16403	16659	16915	17171	17427	17683	17939	18195
LookedUpPhaseASine	FP32	16404	16660	16916	17172	17428	17684	17940	18196
LookedUpPhaseBSine	FP32	16405	16661	16917	17173	17429	17685	17941	18197
CommandCurrentScale	FP32	16406	16662	16918	17174	17430	17686	17942	18198
FeedbackCurrentScale	FP32	16407	16663	16919	17175	17431	17687	17943	18199
PhaseASignal	FP32	16408	16664	16920	17176	17432	17688	17944	18200
PhaseBSignal	FP32	16409	16665	16921	17177	17433	17689	17945	18201
PhaseAOffset	FP32	16410	16666	16922	17178	17434	17690	17946	18202
PhaseBOffset	FP32	16411	16667	16923	17179	17435	17691	17947	18203
PhaseAGain	FP32	16412	16668	16924	17180	17436	17692	17948	18204
PhaseBGain	FP32	16413	16669	16925	17181	17437	17693	17949	18205
MaxMotorRPM	FP32	16414	16670	16926	17182	17438	17694	17950	18206
MaxMotorCurrent	FP32	16415	16671	16927	17183	17439	17695	17951	18207
Reserved	FP32	16416	16672	16928	17184	17440	17696	17952	18208
AverageVelocity	FP32	16417	16673	16929	17185	17441	17697	17953	18209
LockCurrent	FP32	16418	16674	16930	17186	17442	17698	17954	18210
Reserved	FP32	16419	16675	16931	17187	17443	17699	17955	18211
Reserved	FP32	16420	16676	16932	17188	17444	17700	17956	18212
Reserved	FP32	16421	16677	16933	17189	17445	17701	17957	18213
Reserved	FP32	16422	16678	16934	17190	17446	17702	17958	18214
Reserved	FP32	16423	16679	16935	17191	17447	17703	17959	18215

Commutation (continued)

FeedBackEncoder	r/w	The feedback encoder channel.
AngleBetweenPhases	r/w	The phase difference between phase B and Phase A
EncoderShaftPosition	r	Feedback encoder position. This parameter will be reset by the marker pulse of the encoder.
PhaseADacChannel	r/w	Phase A DAC channel.
PhaseBDacChannel	r/w	Phase B DAC channel.
PulsePerRevolution	r/w	Raw encoder counts (without multiplier) per revolution.
PhaseAADCChannel	r/w	Phase A ADC channel.
PhaseBADCChannel	r/w	Phase B ADC channel.
PhaseMarkerOffset	r/w	This parameter applies to sinusoidal mode only. The commutator uses the sum of the current feedback encoder counts and this parameter to calculate the index of the sinusoidal look up table.
ElecRevPerMechRev	r/w	Electrical cycles per mechanical revolution
HallEffectChannel	r/w	Hall effect signals channel. This parameter should equal to FeedBackEncoder if hall-less commutation mode is used.
PhaseLockCount	r/w	This parameter applies to hall-less commutation only. The commutation axis is consider to be locked if the difference of two consecutive reading of the feedback encoder is less than MaxEncDelta for PhaseLockCount of consecutive servo periods.
MaxEncDelta	r/w	This parameter applies to hall-less commutation only. The commutation axis is consider to be locked if the difference of two consecutive reading of the feedback encoder is less than MaxEncDelta for PhaseLockCount of consecutive servo periods.
MaxFollowingErr	r/w	Maximium following error. If the following error is greater than this parameter the commutator will be turned off.
CommutationRegion	r/w	Hall effect signal reading.

Commutation (continued)

CommandSignal	r	Output of servo loop.
SineIndexPerEncCount	r	Feedback encoder position. This parameter will be reset by the marker pulse of the encoder.
LookedUpPhaseASine	r	Phase A SINE value.
LookedUpPhaseBSine	r	Phase B SINE value.
CommandCurrentScale	r/w	Equivalent current amplitude per volt.
PhaseASignal	r	Phase A signal.
PhaseBSignal	r	Phase B signal.
PhaseAOffset	r/w	Phase A offset.
PhaseBOffset	r/w	Phase B offset.
PhaseAGain	r/w	Phase A signal gain.
PhaseBGain	r/w	Phase B signal gain.
MaxMotorRPM	r/w	Maximium motor speed.
MaxMotorCurrent	r/w	Maximium current.
AverageVelocity	r	Average velocity.
LockCurrent	r/w	This parameter applies to hall-less commutation mode only. This parameter specifies current amplitude during start up period.

CMT ANG (Version 1.18 & Up)

Set phase difference

Format: CMT index ANG angle
Group: Global Objects
Units: degree

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the phase difference between the two output signal of the commutator. This command can be issued only when the commutator is off.

The following example will set the phase difference between phase A dac and phase B dac to 240 degrees:

Usage example:

```
10 CMT0 ANG 240
```

CMT DAC DAC (Version 1.18 & Up)

Set DAC Commutator output destination

Format: CMT index DAC phaseAdac DAC phaseBdac
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the sources of commutator output signal. This command can be issued only when the commutator is off.

The following example will set DAC0 and DAC1 as the two phase of commutator output.

Usage example:

```
10 CMT0 DAC0 DAC1
```

CMT ENC ENC (Version 1.18 & Up)

Set commutator source

Format: CMT index ENC feedback position ENC hall
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the source of commutation position feedback and hall signal. The feedback position is used for sinusoidal commutation. The hall signal is used to signal power up state of motor shaft or is used for trapezoidal commutation. This command can be issued only when the commutator is off.

The following example will set ENC0 as commutation position feedback encoder and ENC1 as source of hall signal input.

Usage example:

```
10 CMT0 ENC0 ENC1
```

CMT ERPMR (Version 1.18 & Up)

Set poles_pair

Format: CMT index ERPMR poles_pair
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the number of electrical revolution per mechanical revolution or the number of poles_pair of the motor. This command can be issued only when the commutator is off.

NOTE: The CMT HSEEK command sets this automatically.

The following example will set the poles_pair of the motor to two.

Usage example:

```
10 CMT0 ERPMR 2
```

CMT HSEEK (Version 1.18 & Up)

Set up parameter ERPMR and SHIFT

Format: CMT index HSEEK {speedscale} {CAP capture_register}
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS,INTCAP

This command sets up the parameter for ERPMR and SHIFT automatically. Optionally, the speed to perform the HSEEK can be changed by specifying the speedscale. By default the speed is set by the VEL command. If the speedscale parameter is specified the speed to perform the HSEEK is equal to speedscale * (default speed). The speedscale should be a floating point number between 0 and 1. This command can be issued only when the commutation mode is set to 1.

CAUTION: Unlike other CMT commands, this command will cause the motor to move.

Note: Refer to hardware capture register information in the INTCAP command section. The hardware capture register for the HSEEK is the same as those used in the INTCAP command.

The following example will set the poles_pair and shift parameter.

Usage example:

```
10 CMT0 HSEEK .5
```

CMT LOCK AMP

Set hall-less start up current amplitude

Format: CMT index LOCK AMP current
Group: Global Objects
Unit: amp

See also: CMT

This command sets the current amplitude for hall-less start up. The user must set the "Command Current Scale" parameter to equate voltage to amps to match with the particular servo amp stage being used. Default is 1 for the command scale parameter.

Assume the particular servo amp stage being used will pump out 2 amps for 1 volt input. The following example will set the current amplitude of the hall-less start up mode to .5 amp. The voltage output of the dac channel is .25 volts.

Usage example:

```
10 P16406 = 2
20 CMT0 LOCK AMP 0.5
```

CMT LOCK COUNT

Set up lock position accuracy

Format: CMT index LOCK COUNT num
Group: Global Objects

See also: CMT

This command works with the CMT LOCK RANGE command to set up lock position acuracy for hall-less start up. If the commutator is turned on in hall-less start up mode, the commutator will lock the axis to a known position. If the difference of two consecutive reading of the commutator feedback encoder is within the specified lock range for a consecutive number (lock count) of servo period, the axis is considered to be locked.

By setting up the commutator as the following example , the motor is considered to be locked if the difference of the feedback encoder reading is no greater than 5 counts for consecutive 200 servo period.

Usage example:

```
10 CMT0 LOCK COUNT 200
20 CMT0 LOCK RANGE 5
```

CMT LOCK RANGE

Set up lock position accuracy

Format: CMT index LOCK RANGE num
Group: Global Objects
Unit: amp

See also: CMT

This command works with the CMT LOCK COUNT command to set up lock position acuracy for hall-less start up. If the commutator is turned on in hall-less start up mode, the commutator will lock the motor to a known position. If the difference of two consecutive reading of the commutator feedback encoder is within the specified lock range for a consecutive number (lock count) of servo period, the motor is considered to be locked.

CMT MAX AMP (Version 1.18 & Up)

Set maximum current

Format: CMT index MAX AMP current
Group: Global Objects
Unit: amp

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the maximum peak amplitude of the output signal. The user must set the “Command Current Scale” parameter to equate voltage to amps to match with the particular servo amp stage being used. Default is 1 for the command scale parameter.

Assume the particular servo amp stage being used will pump out 2 amps for 1 volts input. The following example will set the maximum peak amplitude of the output the signal to 10 amps. The actual peak amplitude of the dac channel is 5 volts.

Usage example:

```
10 P16406 = 2
20 CMT0 MAX AMP 10
```

CMT MAX RPM (Version 1.18 & Up)

Set maximum speed

Format: CMT index MAX RPM speed
Group: Global Objects
Unit: rpm

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the maximum speed of the motor. If the actual motor speed exceeds this maximum speed, the commutator will be turned off, and the "motor overspeed" hit flag will be set.

The following example will set the maximum speed of the motor to 4500 rpm.

Usage example:

```
10 CMT0 MAX RPM 4500
```

CMT MODE (Version 1.18 & Up)

Set commutation mode

Format: CMT index MODE mode
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the commutation mode.

Mode = 0	Sinusoidal mode. In this mode the encoder marker should present.
Mode = 1	Trapezoidal mode
Mode = 2	Hall-less start up mode. In this mode, the commutator will drive the motor to jerk to a known position. Once the motor is locked at the known position, the commutator will switch to mode 6.
Mode = 6	Sinusoidal mode without marker. In this mode the encoder marker should not present.
Mode = 8	Trap to sine mode. In this mode, the commutator will power up in trapezoidal mode. Once the encoder marker hits, the commutator will switch to sinusoidal mode. This is the default mode.

The following example will set the commutation mode to sinusoidal mode.

Usage example:

```
10 CMT0 MODE 0
```

CMT OFF (Version 1.18 & Up)

Turn off commutator

Format: CMT index OFF
Group: Global Object

See also: CMT,ATTACH,DAC,ENC,AXIS

This command turns off the commutator.

The following example will turn off the commutator.

Usage example:

```
10 CMT0 OFF
```

CMT ON (Version 1.18 & Up)

Turn on commutator

Format: CMT index ON
Group: Global Objects

See also: CMT,ATTACH,DAC,ENC,AXIS

This command turns on the commutator. If the commutator is still off after this command is issued, refer to the related commutation flags to see what caused the commutator to be turned off. The commutator can not be turned on if there is a commutation related fault.

NOTE: All necessary commutator parameters must be set properly before issuing this command. Failure to do so may result in motor runaway and cause damage or injury.

The following example will turn on the commutator.

Usage example:

```
10 CMT0 ON
```

CMT PPR (Version 1.18 & Up)

Set the encoder lines per revolution of motor

Format: CMT index PPR data
Group: Global Objects
Unit: count

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the encoder lines per revolution of motor. This command can be issued only when the commutator is off.

The following example will set the encoder lines per revolution of motor to 1024.

Usage example:

```
10 CMT0 PPR 1024
```

CMT SHIFT (Version 1.18 & Up)

Set the offset in pluses between the occurence of the marker and the “Hall A”

Format: CMT index SHIFT data
Group: Global Objects
Unit: count

See also: CMT,ATTACH,DAC,ENC,AXIS

This command sets the phase between the marker and the hall A signal.

The following example will set the phase between the marker and the hall A signal to be 100 counts.

NOTE: This parameter is automatically set by the CMT HSEEK command.

Usage example:

```
10 CMT0 SHIFT 100
```

CONFIG

Hardware configuration

Format: CONFIG { command | configlist }
Group: Operating System

See also: ATTACH

This command defines the base hardware installed on the boards, including the encoders and the hardware modules installed in the simm sockets. The command also allows onboard and expansion IO to be redirected for the ACR1200/ACR2000/ACR8000/ ACR8010 boards.

Issuing a CONFIG command without any arguments will display the current configuration. If the IO/XIO have not been redirected, their configurations will not be displayed (IO/XIO not available on ACR1500). For the ACR1500, CONFIG IO MODE, CONFIG IO OUT, and CONFIG IO INPUT configurations will be displayed.

Hardware configurations that have been set by the user with the CONFIG commands will be automatically saved in the EEPROM/FLASH by the processor. FLASH and/or EEPROM commands (FLASH SAVE, FLASH ERASE, ERASE, ESAVE, etc.) have no effect on the saved hardware configuration information.

The following is a list of valid CONFIG command combinations:

`CONFIG`	Display current configuration.
`CONFIG` configlist	Setup hardware configuration. (Axis 0-7)
`CONFIG XAXIS` configlist	Setup hardware configuration. (Axis 8-15) (ACR8020 Only)
`CONFIG CLEAR`	Reset default configuration.
`CONFIG IO`	Configure onboard IO redirection. (ACR1200/ACR2000/8000/8010 only)
`CONFIG XIO`	Configure expansion IO redirection. (ACR1200/ACR2000/8000/8010 only)
`CONFIG IO MODE`	Configure 82C55 IO Mode. (ACR1500 only)
`CONFIG IO OUT`	Configure 82C55 Outputs Logic Polarity. (ACR1500 only)
`CONFIG IO INPUT`	Configure 82C55 Inputs Logic Polarity. (ACR1500 only)

CONFIG

Hardware configuration (continued)

The following is the syntax of the "configlist" argument:

"configlist" = encoders module0 module1 module2

"encoders" = NONE | ENC2 | ENC3* | ENC4 | ENC5* | ENC6 | ENC8 | ENC10*
“module0” = NONE | DAC2 | DAC4 | STEPPER2 | STEPPER4 | DACSTEP2** | DACSTEP4***
“module1” = NONE | DAC2 | DAC4 | STEPPER2 | STEPPER4 | DACSTEP2** | DACSTEP4***
"module2" = NONE | ADC

*NOTE 1: ENC3 is valid only for the ACR1200 board. ENC5 and ENC10 are valid only for the ACR8010 board.

**NOTE 2: DACSTEP2 is currently valid only for the ACR1200 board. This configlist argument is used to define an on-board single channel DAC output and an on-board single channel Stepper output hardware configuration.

***NOTE 3: DACSTEP4 is currently valid only for the ACR1500 board. This configlist argument is used to define a hardware configuration of two channels of on-board DAC outputs and two channels of on-board Stepper outputs.

The default hardware configuration for the ACR1200/ACR2000/ACR8000/ACR8010 boards is:

```
CONFIG ENC8 DAC4 DAC4 ADC8****
```

The default configuration for ACR1500 board is:

```
CONFIG ENC8 DAC4 DAC4 ADC8****
CONFIG IO MODE 0
CONFIG IO INPUT NEG
CONFIG IO OUT NEG
```

****Note 4: The default hardware configuration is the same for all Acroloop Motion Control Boards. Since the hardware configuration of the Acroloop boards is user dependant, it is the user’s responsibility to set the correct hardware configuration.

CONFIG

Hardware configuration (continued)

Usage example 1 (ACR8000/ACR8010):

This example defines six encoder channels, a two channel DAC module, a four channel stepper module, and no analog input module on an ACR8000 or ACR8010 board:

```
CONFIG ENC6 DAC2 STEPPER4 NONE
```

Usage example 2 (ACR2000):

This example defines four encoder channels, a two channel DAC module, and no analog input option on an ACR2000 board:

NOTE: Module 1 is not used on an ACR2000 board and should be set to “NONE”.

```
CONFIG ENC4 DAC2 NONE NONE
```

Usage example 3 (ACR1500):

This example defines four encoder channels, four channels of on-board DAC outputs, and a 12-bit or 16 bit analog input module on an ACR1500 board:

NOTE: Module 1 is not used on an ACR1500 board and should be set to “NONE”.

```
CONFIG ENC4 DAC4 NONE ADC8
```

Usage example 4 (ACR1200):

This example defines three encoder channels, an on-board single channel DAC output, an on-board single channel stepper output, and no analog input module on an ACR1200 board:

NOTE: Module 1 is not used on an ACR1200 board and should be set to “NONE”.

```
CONFIG ENC3 DACSTEP2 NONE NONE
```

Usage example 5 (ACR8020):

This example defines eight encoder channels, two four channel DAC modules and eight channel ADC on ACR8020 main board. The expansion board is configured to four encoder channels, four DAC channels, four stepper channels and eight ADC channels.

```
CONFIG ENC8 DAC4 DAC4 ADC8
CONFIG XAXIS ENC4 DAC4 STEPPER4 ADC8
```

CONFIG CLEAR

Reset Default Configuration

Format: CONFIG CLEAR
Group: Operating System

See also: ATTACH

This command sets the hardware configuration to default.

The default configuration for ACR1200/ACR2000/ACR8000/ACR8010 boards is:

```
CONFIG ENC8 DAC4 DAC4 ADC8
```

The default configuration for ACR1500 board is:

```
CONFIG ENC8 DAC4 DAC4 ADC8
CONFIG IO MODE 0
CONFIG IO INPUT NEG
CONFIG IO OUT NEG
```

The following example sets the hardware configuration to default and stores this information to EEPROM/FLASH:

Usage example:

```
CONFIG CLEAR
```

CONFIG IO (Version 1.17.03 & Up)

Onboard IO redirection

Format: CONFIG IO input destination output source
Group: Operating System

See also: ATTACH

This command must be used with in conjunction with a CONFIG XIO command. See usage example below.

This command redirects the onboard digital IO. The “input destination” argument tells the control where to place the bits read from the onboard inputs. The “output source” argument tells the control where to get the bits that will be sent to the onboard outputs.

The default onboard IO redirection is:

```
CONFIG IO P4096 P4097
```

See Usage Example in CONFIG XIO command.

CONFIG XIO (Version 1.17.03 & Up)

Expansion IO redirection

Format: CONFIG XIO board input destination output source
Group: Operating System

See also: ATTACH

This command must be used with in conjunction with a CONFIG IO command. See usage example below.

This command redirects the expansion digital IO. The “board” argument indicates which expansion IO board is to be redirected. The “input destination” argument tells the control where to place the bits read from the expansion inputs. The “output source” argument tells the control where to get the bits that will be sent to the expansion outputs.

The default expansion IO redirections are:

```
CONFIG XIO0 P4104 P4105
CONFIG XIO1 P4106 P4107
CONFIG XIO2 P4108 P4109
CONFIG XIO3 P4110 P4111
```

The following example redirects onboard IO to Expansion Board 0 and Expansion Board 0 to onboard IO:

Usage example:

```
CONFIG IO P4104 P4105
CONFIG XIO0 P4096 P4097
```

CONFIG IO MODE (ACR1500) (Version 1.18.02 & Up)

Onboard 82C55 IO mode

Format: CONFIG IO MODE {io mode}
Group: Operating System

See also: ATTACH

This command selects the Programmable Peripheral Interface IC (82C55) I/O mode of operation. The “io mode” argument tells the control how to configure the 82C55 IC’s input/output ports.

The default mode of operation for the ACR1500 Digital I/O is Mode 0 (24 Inputs/24 Outputs).

The following table provides the IO Mode configuration information, as well as the Bit Flag location for each group of inputs and outputs.

The Bit Flag locations for the ACR1500 TTL Digital I/O are mapped to the standard Input Bit Flags 0 thru 31 (parameter P4096) and Output Bit Flags 32 thru 63 (parameter P4097). When the number of inputs or outputs configured exceeds 32, they are mapped to the Expansion Input Bit Flags 256 thru 271 (parameter P4104) and/or Expansion Output Bit Flags 288 thru 303 (parameter P4105).

CONFIG IO MODE	I/O00-I/O07	I/O08-I/O15	I/O16-I/O23	I/O24-I/O31	I/O32-I/O39	I/O40-I/O47
0	INPUTS BIT0-7	INPUTS BIT8-15	INPUTS BIT16-23	OUTPUTS BIT32-39	OUTPUTS BIT40-47	OUTPUTS BIT48-55
1	INPUTS BIT0-7	INPUTS BIT8-15	INPUTS BIT16-23	OUTPUTS BIT32-39	OUTPUTS BIT40-47	INPUTS BIT24-31
2	INPUTS BIT0-7	INPUTS BIT8-15	OUTPUTS BIT56-63	OUTPUTS BIT32-39	OUTPUTS BIT40-47	OUTPUTS BIT48-55
3	INPUTS BIT0-7	INPUTS BIT8-15	INPUTS BIT16-23	OUTPUTS BIT32-39	INPUTS BIT256-263	INPUTS BIT24-31
4	INPUTS BIT0-7	OUTPUTS BIT288-295	OUTPUTS BIT56-63	OUTPUTS BIT32-39	OUTPUTS BIT40-47	OUTPUTS BIT48-55
5	INPUTS BIT0-7	INPUTS BIT8-15	INPUTS BIT16-23	INPUTS BIT264-271	INPUTS BIT256-263	INPUTS BITS24-31
6	OUTPUTS BIT296-303	OUTPUTS BIT288-295	OUTPUTS BIT56-63	OUTPUTS BIT32-39	OUTPUTS BIT40-47	OUTPUTS BIT48-55

The following example sets the IO Mode to Mode 2 (16 Inputs / 32 Outputs):

Usage example:

```
CONFIG IO MODE 2
```

CONFIG IO INPUT (ACR1500) (Version 1.18.02 & Up)

Configures inputs logic polarity

Format: CONFIG IO INPUT {polarity}
Group: Operating System

See also: ATTACH

This command selects the input TTL logic polarity to be decoded by the board. The polarity applies to all inputs. The “polarity” argument indicates the selected polarity as follows:

Polarity Argument	ON Logic Level	OFF Logic Level
NEG	Logic Level Low	Logic Level High
POS	Logic Level High	Logic Level Low

The default IO inputs polarity is:

```
CONFIG IO INPUT NEG
```

The following example selects the IO inputs to positive logic polarity:

Usage example:

```
CONFIG IO INPUT POS
```

CONFIG IO OUT (ACR1500) (Version 1.18.02 & Up)

Configures outputs logic polarity

Format: CONFIG IO OUT {polarity}
Group: Operating System

See also: ATTACH

This command selects the output TTL logic polarity to be decoded by the board. The polarity applies to all outputs. The “polarity” argument indicates the selected polarity as follows:

Polarity Argument	ON Logic Level	OFF Logic Level
NEG	Logic Level Low	Logic Level High
POS	Logic Level High	Logic Level Low

The default IO outputs polarity is:

```
CONFIG IO OUT NEG
```

The following example selects the IO outputs to positive logic polarity:

Usage example:

```
CONFIG IO OUT POS
```

CPU

Display processor loading

Format: CPU
Group: Operating System

See also: PERIOD, DIAG

This command displays the processor load as a percentage of the foreground and background timing. Background time consists of servo loop updates, velocity profiles and axis position interpolation. Foreground time is the time left over for the execution of user programs. High foreground percentages usually mean that the user programs are going to execute faster.

This command is used along with the PERIOD command to control the foreground/background percentages in the system.

Usage example:

```
CPU
```

DAC

Analog output control

Format1: DAC index GAIN { gain }
Format2: DAC index OFFSET { offset }
Group: Global Objects

See also: AXIS, ENC

The DAC commands give direct access to the D/A converter software adjustments. Issuing these commands without the final argument will display their current settings. The default GAIN is 3276.8 dac_units / volt and the default OFFSET is 0.0 volts.

Note that the output voltage is inverted in the output stage of the hardware, therefore the default DAC GAIN will physically send out a negative voltage for positive settings.

The following example sets offset on DAC3 to 125 milivolts:

Usage example:

```
DAC3 OFFSET 0.125
```

DEC

Set deceleration ramp

Format: DEC { rate }
Group: Velocity Profile
Units: units / second^2

See also: ACC, STP, VEL, IVEL, FVEL, PPU

The DEC command sets the master deceleration used to ramp from higher to lower speeds. Issuing a DEC command with no argument will display the current setting. The default deceleration ramp is 20000 units / second^2.

The DEC command can be also be used in expressions as follows:

```
DV0 = SQRT(DEC)
DEC = ACC
```

Setting DEC to zero disables the deceleration ramp. In the case where the motor needs to slow down (such as with an FOV command), it will try to do so instantaneously.

The following example sets up a deceleration ramp of 10000 units per second^2:

Program Usage example:

```
10 DEC 10000
```

DEF

Didspaly the defined variables

Format: DEF { number }
Group: Operating System

See also: DEFINE

This command will display the currently defined user variables.

Usage example:

```
SYS>DEF
#DEFINE LED         BIT96
#DEFINE myflag      BIT32
#DEFINE TRUE        1
#DEFINE Counter     LV2
#DEFINE loop        LV4
```

#DEFINE

Define variables

Format: #DEFINE { name } { parameter }
Group: Operating System

See also: DEFINE

This command is used to define user variables.

Usage example:

```
#DEFINE LED        BIT96
#DEFINE myflag     BIT32
#DEFINE TRUE       1
#DEFINE Counter    LV2
#DEFINE CurrentPos       P12288
```

DETACH

Clear attachments

Format: DETACH { ALL }
Group: Operating System

See also: ATTACH

This command cancels the master and slave attachments created with the ATTACH command. The ATTACH and DETACH commands can be issued from within a program, but special care must be taken to prevent errors that will halt the program.

The DETACH ALL command can be issued from anywhere in the system and will detach all slaves from all masters and all masters from all programs.

The following example detaches the master and slaves from the current program:

Usage example:

```
DETACH
```

DGAIN

Set derivative gain

Format: DGAIN { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / pulses / second

See also: DWIDTH, PGAIN, IGAIN, FFVEL, FFACC

This command modifies the value used in the PID algorithm to control derivative gain. Issuing a DGAIN command to an axis without an argument will display the current setting for that axis. The default gain is 0.0 for all axes.

The following example sets X axis derivative gain to 0.0001 volts / pulses / second:

Usage example:

```
DGAIN X0.0001
```

DGAIN SMOOTH

Take away humming noise from the torque motor due to DAGIN.
Axis parameter **"DGAIN Smooth"** is used to subdue the humming noise in the torque motor due to DGAIN. The Default value is 0, which means no smoothing is applied. The user may typically change this value from 0 to 5. The DGAIN command must be used after changing this parameter to make this change effective.

Usage example:

```
REM The dgain term will be averaged over 4 samples.
P12402 = 4
DGAIN X0.0001
```

DIAG

Display system diagnostics

Format: DIAG
Group: Operating System

See also: PERIOD, CPU

This command displays the status of various power conditions, as well as indicating the option modules present for the ACR1200, ACR2000 and ACR8010 boards. The output of this command is likely to change as more system diagnostics are added to the operating system. In Firmware Version 1.18 and up, these status bits are also available as a parameter, P7044 (See Parameter Reference, Appendix A).

The following describes the diag command results for the ACR1200, ACR1500, ACR2000, ACR8000, and ACR8010 boards, including the ACR1200, ACR2000 and the ACR8010 option modules.

ACR8000 Board DIAG Command Definitions

The following will be displayed when invoking the DIAG command on an ACR8000 Board.

+24V: PASS
+5V: PASS
+12V: PASS
-12V: PASS

Where:

+24V: Isolated external voltage provided for the optoisolation circuitry on the ACR8000 board.

PASS: External voltage present
FAIL: No external voltage present

+5V: On-board isolated +5VDC voltage provided for the optoisolation circuitry on the ACR8000 board. The isolated +5VDC is generated from the isolated external supplied voltage.

PASS: On-board isolated +5VDC voltage present
FAIL: No voltage present

+12V: +12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

-12V: -12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

DIAG

Display system diagnostics (continued)

The following describes the diag command results for the ACR1200 board.

ACR1200 Board DIAG Command Definitions

The following will be displayed when invoking the DIAG command on an ACR1500 Board.

EXT: PASS
ISO: PASS
VDD: PASS
VEE: PASS
BCL: PASS
BCF: PASS
ENC: PASS
STP: PASS

Where:

EXT: Isolated external voltage provided for the optoisolation circuitry on the ACR8010 Motherboard.

PASS: External voltage present
FAIL: No external voltage present

ISO: On-board isolated +5VDC voltage provided for the optoisolation circuitry on the ACR8010 Motherboard. The isolated +5VDC is generated from the isolated external supplied voltage.

PASS: On-board isolated +5VDC voltage present
FAIL: No voltage present

VDD: +12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

VEE: -12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

Display system diagnostics (continued)

ACR1200 Board DIAG Command Definitions (continued)

BCL: 1000mAH Lithium Battery BT1 voltage low indicator. This is a warning indicator that battery voltage is approaching minimum requirements for SRAM back-up. Minimum SRAM data retention voltage is 2.0VDC. BT1 should be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.5VDC
FAIL: BT1 is between 2.3 and 2.5 VDC (when BCF displays PASS)

BCF: 1000maH Lithium Battery BT1 voltage fail indicator. This is a warning indicator that battery voltage is below requirements for SRAM back-up (minimum SRAM data retention voltage is 2.0VDC). BT1 must be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.2VDC
FAIL: BT1 is between 2.0 and 2.2 VDC.

ENC: Fused Encoder +5VDC available at the P1 encoder connector.

PASS: Voltage present
FAIL: No voltage present

STP: Fused Stepper +5VDC available at the P2 analog connector.

PASS: Voltage present
FAIL: No voltage present

DIAG

Display system diagnostics (continued)

The following describes the diag command results for the ACR1500 board.

ACR1500 Board DIAG Command Definitions

The following will be displayed when invoking the DIAG command on an ACR1500 Board.

Encoder Power

EVCC: PASS

Where:

EVCC: Fused +5VDC available at the P1 encoder connector.

PASS: Voltage present
FAIL: No voltage present

DIAG

Display system diagnostics (continued)

ACR2000 Motherboard DIAG Command Definitions

The following will be displayed when invoking the DIAG command on an ACR2000 Board.

Optoisolated Power
EXT: PASS
ISO: PASS

Where:

EXT: Isolated external voltage provided for the optoisolation circuitry on the ACR2000 Motherboard.

PASS: External voltage present
FAIL: No external voltage present

ISO: On-board isolated +5VDC voltage provided for the optoisolation circuitry on the ACR2000 Motherboard. The isolated +5VDC is generated from the isolated external supplied voltage.

PASS: On-board isolated +5VDC voltage present
FAIL: No voltage present

DIAG

Display system diagnostics (continued)

ACR2000 ACRCOMM Comm Board DIAG Command Definitions

In addition to the ACR2000 motherboard diagnostics, the following will be displayed when invoking the DIAG command on an ACR2000 Board with an ACRCOMM module.

COMM Board Detected
BID: 0
VDD: PASS
VEE: PASS
BCL: PASS
BDF: PASS

Where:

BID: Board ID number for a COMM board.

0: COMM Board ID Number

VDD: +12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

VEE: -12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

BCL: 1000mAH Lithium Battery BT1 voltage low indicator. This is a warning indicator that battery voltage is approaching minimum requirements for SRAM back-up. Minimum SRAM data retention voltage is 2.0VDC. BT1 should be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.5VDC
FAIL: BT1 is between 2.3 and 2.5 VDC (when BCF displays PASS)

BCF: 1000maH Lithium Battery BT1 voltage fail indicator. This is a warning indicator that battery voltage is below requirements for SRAM back-up (minimum SRAM data retention voltage is 2.0VDC). BT1 must be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.2VDC
FAIL: BT1 is between 2.0 and 2.2 VDC.

DIAG

Display system diagnostics (continued)

ACR8010 Motherboard DIAG Command Definitions

The following will be displayed when invoking the DIAG command on an ACR8010 Board.

Optoisolated Power
EXT: PASS
ISO: PASS
VDD: PASS
VEE: PASS
BCL: PASS
BCF: PASS

Where:

EXT: Isolated external voltage provided for the optoisolation circuitry on the ACR8010 Motherboard.

PASS: External voltage present
FAIL: No external voltage present

ISO: On-board isolated +5VDC voltage provided for the optoisolation circuitry on the ACR8010 Motherboard. The isolated +5VDC is generated from the isolated external supplied voltage.

PASS: On-board isolated +5VDC voltage present
FAIL: No voltage present

VDD: +12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

VEE: -12VDC supply voltage.

PASS: Voltage present
FAIL: No voltage present

BCL: 1000mAH Lithium Battery BT1 voltage low indicator. This is a warning indicator that battery voltage is approaching minimum requirements for SRAM back-up. Minimum SRAM data retention voltage is 2.0VDC. BT1 should be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.5VDC
FAIL: BT1 is between 2.3 and 2.5 VDC (when BCF displays PASS)

ACR8010 Motherboard DIAG Command Definitions (continued)

BCF: 1000maH Lithium Battery BT1 voltage fail indicator. This is a warning indicator that battery voltage is below requirements for SRAM back-up (minimum SRAM data retention voltage is 2.0VDC). BT1 must be replaced. (AMCS P/N PS006, Panasonic P/N CR2477N)

PASS: BT1 > 2.2VDC
FAIL: BT1 is between 2.0 and 2.2 VDC.

DIAG

Display system diagnostics (continued)

ACR1200, ACR2000, and ACR8010 ACRIO Expansion I/O Board DIAG Command Definitions

In addition to the ACR1200, ACR2000, and the ACR1200 motherboard diagnostics, the following will be displayed when invoking the DIAG command on an ACR1200, ACR2000 or an ACR8010 Board with an ACRIO module.

When multiple expansion I/O boards are present, the board number will be listed with diagnostic information present for each board.

XIO Board "#" Detected
BID: 16
EXT: PASS
ISO: PASS

Where:

: XIO Board Number (1 thru 4) as selected by J1 and J2 on the ACRIO boards.

BID: Board ID number for an ACRIO board. This number is the same for all XIO boards.

16: ACRIO Board ID Number

EXT: Isolated external voltage provided for the optoisolation circuitry on the ACRIO board.

PASS: External voltage present
FAIL: No external voltage present

ISO: On-board isolated +5VDC voltage provided for the optoisolation circuitry on the ACRIO board. The isolated +5VDC is generated from the isolated external supplied voltage.

PASS: On-board isolated +5VDC voltage present
FAIL: No voltage present

Usage example:

```
DIAG
```

DIM

Allocate memory

System Level Formats:

DIM PROG prognum (size)	Allocate program memory
DIM PLC plcnum (size)	Allocate PLC memory
DIM P (count)	Allocate globals (64 bit floating points)
DIM FIFO (size)	Allocate FIFO buffer **(Version 1.17.03 & Up – ACR1500/Acr2000/ACR8000/ACR8010 only)**
DIM COM1 (size)	Allocate COM1 buffer **(Version 1.17.03 & Up)**
DIM COM2 (size)	Allocate COM2 buffer **(Version 1.17.03 & Up)**
DIM DPCB (size)	Allocate DPCB buffer **(Version 1.18.06 & Up – ACR8020 Only)**
DIM LOGGING (size)	Allocate non-volatile, battery backed up memory for logging parameters **(Version 1.18 & Up – ACR1200/ACR1500/ACR2000/ACR8010/ACR8020 only)**
DIM	Display current system dimensions

Program Level Formats:

DIM LV (count)	Allocate long variables (32 bit integers)
DIM SV (count)	Allocate singles (32 bit floating points)
DIM DV (count)	Allocate doubles (64 bit floating points)
DIM $V (count, length)	Allocate strings (8 bit characters)
DIM LA (number)	Allocate long array references
DIM LA array (count)	Allocate long array
DIM SA (number)	Allocate single array references
DIM SA array (count)	Allocate single array
DIM DA (number)	Allocate double array references
DIM DA array (count)	Allocate double array
DIM $A (number)	Allocate string array references
DIM $A array (count, length)	Allocate string array
DIM MBUF (count)	Allocate multiple buffers for motion profiler
DIM DEF (count)	Allocate defined variable names for alias
DIM	Display current program dimensions

Group: Memory Control
See also: CLEAR, MEM

This command allocates memory space for programs, buffers, variables, and arrays.

For program allocation, "program" is the program number being allocated and "size" is the number of bytes you wish to allocate to the program. This use of the DIM command can only be done from the system level.

Stream buffers (FIFO, COM1, COM2, DPCB) default to 256 bytes, but may be redimensioned from the system level. The “size” is the number of bytes to allocate for that buffer. After the buffer resizing is complete, the appropriate “Stream Redimensioned”

flag will be set. Issuing a CLEAR command for a stream will return it to the default 256 byte storage area. Minimum allocation for the stream buffers is 256 bytes, each.

DIM

Allocate memory (continued)

For variable allocation, "count" is the number of variables of that type that are required in your program. For strings, "length" is the maximum number of characters that the allocated string will be able to hold. This use of the DIM command can be done from either the program level or within a program that is running.

Array allocation is similar to variable allocation, but is done in two parts. First the array references are allocated, where "number" is the number of arrays that are required. This allocates and sets up a table of array references. The individual arrays are then allocated, where "array" is the reference of the array to be allocated and "count" is the number of variables in that array.

Once memory has been allocated, it can not be redimensioned to a different size without first doing a CLEAR to erase all dimensioning. CLEAR from the system level will free memory allocated to all programs. The programs must be empty for this to work. CLEAR from the program level, or within a program, frees memory allocated in the program space for variable and array usage.

The total RAM available for user allocation is 64k x 8 bytes for the ACR8000, 128k x 8 bytes for the ACR1200/ACR1500/ACR2000 and 512k x 8 bytes for the ACR8010/ACR8020 and Expanded Memory ACR2000. The system default allocates 8 blocks of 16k x 8 to programs 0 through 7, respectively. If this is not satisfactory, you must issue a CLEAR command from the system level and use the DIM PROG format to allocate memory as required.

By default, the logging parameters will be stored to system memory (P20480-P20487) and this data will be lost when power is removed from the card. If LOGGING is dimensioned, then the logging parameters will be stored to non-volatile, battery backed up memory. Logging parameters are available for the ACR1200, ACR1500, ACR2000, and ACR8010 boards only.

DIM MBUF command is used to allocate memory for the moves to be buffered by the master profiler. This buffer is part of the master and must be allocated inside the program to which the master is attached. The CLEAR command can be used to de-allocate all the memory at the program level. If the program contains any line numbers that need to be downloaded, then the DIM MBUF command should also be downloaded with the program line number.

DIM DEF comamd is used to allocated memory for defining aliases for the variables.

The following shows memory usage by various data and program structures:

LV variables	4 bytes per element (32 bit integers)
SV variables	4 bytes per element (32 bit floating point)
DV variables	8 bytes per element (64 bit floating point)
$V variables	4 bytes + 1 byte per character

DIM

Allocate memory (continued)

Array references	4 bytes per array reference + 4 bytes
LA arrays	4 bytes per element + 4 bytes
SA arrays	4 bytes per element + 4 bytes
DA arrays	8 bytes per element + 4 bytes
$A arrays	1 byte per character

Commands	4 bytes per command	
Parametric Statements	4 bytes per operator	
Long Constants	4 bytes per constant	(32 bit integer)
Single Constants	4 bytes per constant	(32 bit floating point)
Double Constants	8 bytes per constant	(64 bit floating point)
String Constants	4 bytes + 1 byte per character	
Subroutine Calls	4 bytes per level	

Usage example:

```
SYS
CLEAR
DIM PROG0(32768)
DIM PROG1(10000)
DIM DEF (50)
PROG0
10 DIM LV50
20 DIM DA(2)
30 DIM DA0(100)
40 DIM DA1(50)
50 DIM $V(10,80)
60 DIM MBUF (30)
```

DIN (Version 1.18.06 Update 05)

Dead Zone Integral Initial Negative Value

Format: DIN { axis { value } } { axis { value } } ...
Group: Servo Control
Units: Volts

See also: DZL, DZU, DIP

This command sets the dead zone integral initial negative value of an axis. Each time the servo loop comes out of dead zone with a negative following error, the Integrator of the PID loop gets the DIN value as its initial value. Issuing a DIN command to an axis without an argument will display the current setting for that axis. The default value is 0.

The following example sets the X axis DIN value to –1.5 volt.

Usage example:

```
DIN X -1.5
```

DIP (Version 1.18.06 Update 05)

Dead Zone Integral Initial Positive Value

Format: DIP { axis { value } } { axis { value } } ...
Group: Servo Control
Units: Volts

See also: DZL, DZU, DIN

This command sets the dead zone integral initial positive value of an axis. Each time the servo loop comes out of dead zone with a positive following error, the Integrator of the PID loop gets the DIP value as its initial value. Issuing a DIP command to an axis without an argument will display the current setting for that axis. The default value is 0.

The following example sets the X axis DIP value to 2.2 volt.

Usage example:

```
DIP X 2.2
```

DWIDTH

Set derivative sample period

Format: DWIDTH { axis { value } } { axis { value } } ...
Group: Servo Control
Units: seconds

See also: DGAIN

This command modifies the value used in the PID algorithm to control the derivative sampling rate. Issuing a DWIDTH command to an axis without an argument will display the current setting for that axis. The default width is 0.0 for all axes.

Derivative sampling width determines how often the following error is sampled when calculating the derivative term. Setting this value to zero will set the sampling to occur at the servo interrupt rate set with the PERIOD command.

The following example sets the X axis derivative sample width to 1 millisecond:

Usage example:

```
DWIDTH X0.0001
```

DWL

Delay for a given period

Format: DWL time
Group: Logic Function
Units: seconds

This command suspends program execution for a given amount of time. The minimum dwell time is 1 millisecond.

The following example will delay for 1.25 seconds.

Usage example:

```
10 DWL 1.25
```

DZL (Version 1.18.06 Update 05)

Dead Zone Lower Limit

Format: DZL {axis {value}} {axis {value}}....
Group: Servo Control
Units: pulses

See also: DZU, DIP, DIN

This command sets the lower limit for the dead zone of an axis. The DZL value should be less than DZU. Issuing a DZL command to an axis without an argument will display the current setting for that axis. The default value is 0.

Once the current commanded position of the axis is eqaul to the target position of the axis, the dead zone mechanism becomes active. Then as soon as the following error becomes less the DZL, the DAC output goes to zero and stays there till the following error becomes greater than DZU.

The following example sets the X axis dead zone lower limit to 5 pulses.

Usage example:

```
DZL X 5
```

DZU (Version 1.18.06 Update 05)

Dead Zone Upper Limit

Format: DZU { axis { value } } { axis { value } } ...
Group: Servo Control
Units: pulses

See also: DZL, DIP, DIN

This command sets the upper limit for the dead zone of an axis. The axis will remain in the dead zone with DAC output of zero, till the following error becomes greater than DZU. Note that DZU's value should be greater than DZL. Issuing a DZU command to an axis without an argument will display the current setting for that axis. The default value is 0.

The following example sets the X axis dead zone upper limit to 12 pulses.

Usage example:

```
DZU X 12
```

ECHO

Control character echoing

Format: ECHO { mode }
Group: Operating System

This command controls the prompt and echo on a communication channel. Issuing an ECHO command without an argument displays the current setting. The default setting for echo control is 1 for all communication channels.

The following table lists the valid echo modes:

Echo Mode	Command Prompt	Error Messages	Character Echo
0	ON	ON	OFF
1	ON	ON	ON
2	ON	OFF	OFF
3	ON	OFF	ON
4	OFF	ON	OFF
5	OFF	ON	ON
6	OFF	OFF	OFF
7	OFF	OFF	ON

Table 3.8 Echo control modes

The following example turns off error message reporting:

Usage example:

```
ECHO 3
```

ELOAD

Load system parameters

Format: ELOAD { ALL }
Group: Nonvolatile

See also: ESAVE, ERASE, PBOOT, BRESET

This command loads the system parameters that were stored in EEPROM (ACR8000 only) or FLASH system parameter section (for all other boards) using the ESAVE command.

Note that the "ALL" command modifier is optional.

The values loaded with ELOAD include:

1. System attachments
2. Master parameters
   ACC, DEC and STP ramps
   VEL, FVEL and IVEL values
3. Axis parameters
   Gain and limit settings
   PPU and VECDEF values
   ON / OFF states
4. Encoder multipliers
5. DAC gains and offsets
6. ADC mode, gains and offsets

NOTE: Program memory allocation is stored in battery-backup RAM, not in the EEPROM.

NOTE: FLASH commands (FLASH SAVE, FLASH ERASE, etc.) have no effect on the saved system parameters.

Usage example:

```
ELOAD
```

ENC

Direct ENC manipulation

Format1: ENC index RES { preload }
Format2: ENC index MULT { multiplier }
Group: Global Objects

See also: AXIS, DAC, RES, MULT

The ENC commands give direct access to encoder reset and multiplier setup without going through the axes. Issuing these commands without the final argument will display their current settings. See the corresponding base commands for descriptions:

The following example sets the hardware for ENC5 to 4x multiplication:

Usage example:

```
ENC5 MULT 4
```

ENC RD ABS (Version 1.18.04 & Up)

Read Yaskawa Absolute Encoder (ACR8010 only)

Format: ENC index READ ABS #io1 #io2
Group: Global Objects

See also: AXIS

This command is only available on the ACR8010.

This command is used to read absolute encoder data from a Yaskawa Sigma Series Absolute Encoder. "io1" is the ACR8010 output used to control the SEN signal to the Yaskawa absolute encoder. "io2" is the ACR8010 output that is used to control the SERVO_ON signal. Refer to the Yaskawa Servopack User's Manual for definition of these signals.

The absolute encoder data consists of serial data and initial incremental pulses. The serial data indicates how many turns the motor shaft has made from the reference position. The initial incremental pulses are the remaining absolute position data, within one revolution.

Before the absolute encoder is read, the axis to which the absolute encoder is attached must be turned off. This will prevent the axis from running away, because the encoder count will be changing while the absolute data is read. The correct sequence for reading the absolute encoder data is as follows:

1. Turn off axis
2. Read absolute data
3. Set encoder count and current position to proper value
4. Turn axis back on

The serial data can be read from the Encoder "ABS Revolution" parameter and the initial incremental pulses can be read from the Encoder "Encoder Position" parameter.

If the absolute encoder data is read successfully, Encoder "ABS DATA READY" flag will be set. Otherwise, Encoder "ABS DATA ERROR" flag will be set.

The absolute encoder position can be determined using the following formula:

$P_E = P_O + mult \times P_A \times R \times K$

Where P_E is the absolute encoder position
P_A is the serial data (the number of revolution)
R is the number of pulses per encoder revolution
mult is the encoder multiplier
P_O is the initial incremental pulses (The absolute position within one revolution)
K = -1 if the SERVOPACK is at forward rotation mode
K = 1 if the SERVOPACK is at reverse rotation mode

Read Yaskawa Absolute Encoder, continued

Usage Example 1 assumes absolute encoder ENC1 as position feedback on axis 0 (X) and the YASKAWA SERVOPACK is set as reverse rotation mode. Set output 32 will bring the SEN signal to low level. Set output 33 will enable SERVO_ON signal. The pulses_per_revolution of the encoder is 1024.

Usage Example 1:

```
10 enc1 mult 4
20 axis0 off
30 enc1 read abs #32 #33
40 p1 = p6160 + 4 * 1024 * p6164
50 res x (p1)
60 axis0 on
70 set 33
```

NOTE:

When the Yaskawa Servopack is powered-up, it takes some time for the Servopack to initialize and be ready to send absolute encoder information. It may be necessary to insert a time delay (using the DWL command), at the beginning of a program, to compensate for this time before the ACR8010 can read the absolute encoder data. Refer to the Yaskawas Servopack User's Manual for timing information.

END

End of program execution

Format: END
Group: Program Flow

See also: END,PROGRAM

This command will cause a program to terminate. If the program executes to the last line, an END command is automatically done. The END command is used to terminate the program in the middle based on some condition. Issuing an END command from the command line will not stop the execution of a program, use the HALT command instead.

Usage example:

```
100 END
```

ERASE

Erase the system parameters

Format: ERASE { ALL }
Group: Nonvolatile

See also: ELOAD, ESAVE, PBOOT, BRESET

This command erases all system parameter information from the EEPROM (ACR8000) or FLASH system parameter section (for all other boards). The next time power is applied to the card, system defaults are used instead of the EEPROM values.

Note that the "ALL" command modifier is optional.

NOTE: This command should be used with caution since it destroys setup information.

NOTE: Program memory allocation is stored in battery-backup RAM, not in the EEPROM.

NOTE: FLASH commands (FLASH SAVE, FLASH ERASE, etc.) have no effect on the system parameters.

Usage example:

```
ERASE
```

ESAVE

Save system parameters

Format: ESAVE { ALL }
Group: Nonvolatile

See also: ELOAD, ERASE, PBOOT, BRESET

This command stores system parameters into EEPROM (ACR8000) or FLASH system parameter section (for all other boards) to be retrieved on power-up or by issuing an ELOAD command.

Note that the "ALL" command modifier is optional.

The values stored by ESAVE include:

1. System attachments
2. Master parameters
   ACC, DEC and STP ramps
   VEL, FVEL and IVEL values
3. Axis parameters
   Gain and limit settings
   PPU and VECDEF values
   ON / OFF states
4. Encoder multipliers
5. DAC gains and offsets
6. ADC mode, gains and offsets

NOTE: Program memory allocation is stored in battery-backup RAM, not in the EEPROM.

NOTE: FLASH commands (FLASH SAVE, FLASH ERASE, etc.) have no effect on the saved system parameters.

Usage example:

```
ESAVE
```

EXC

Set excess error band

Format: EXC { axis { value } } { axis { (value1, value2) } } ...
Group: Axis Limits
Units: units

See also: IPB, PPU

This command sets the following error limits monitored by the "not excess error" flags. When the following error of a given axis is within its excess error band, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if all of its slaves are within their excess error bands.

Issuing the EXC command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "value1" and the negative limit to "value2". The default for both is 0.0 for all axes.

The following is a table of 'not excess error' flags:

MASTER	BIT
0	529
1	561
2	593
3	625
4	657
5	689
6	721
7	753

AXIS	BIT
0	769
1	801
2	833
3	865
4	897
5	929
6	961
7	993

Table 3.9 'Not excess error' flags

Usage example:

This example sets an excess error band of ±0.5 units for X and Y axes.

```
EXC X0.5 Y0.5
```

F

Set velocity in units / minute

Format: F { rate }
Group: Velocity Profile
Units: units / minute

See also: VEL, ACC, DEC, STP, FOV, PPU

This command is an alternative to using the VEL command. The F command works identically to the VEL command except for a scaling modifier that translates the move velocity into units / minute.

The following example sets the velocity to 600 units per minute (same as VEL 10) :

Usage example:

```
F600
```

FBVEL

Set velocity feedback gain

Format: FBVEL { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / pulses / second

See also: ATTACH AXIS

This sets the velocity feedback gain for an axis. Issuing an FBVEL command to an axis without an argument will display the current setting for that axis. The default velocity feedback gain is 0.0 for all axes.

The velocity feedback gain is multiplied by the velocity (derivative) of the velocity feedback source attached to the axis with the ATTACH AXIS command. This value is then subtracted from the control signal before it enters the digital filters.

The result is a software tachometer based on encoder or analog signal input. A typical use for this would be a dual-feedback loop where an encoder on the load is used for the position feedback and an encoder on the motor shaft is used to dampen velocity response.

The following example sets X axis velocity feedback gain to 0.0001 volts / pulses / second:

Usage example:

```
FBVEL X0.0001
```

FFACC

Set feedforward acceleration

Format: FFACC { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / pulses / second^2

See also: FFVEL, PGAIN, IGAIN, DGAIN, PPU

This sets the acceleration feedforward for an axis. Issuing an FFACC command to an axis without an argument will display the current setting for that axis. The default acceleration feedforward gain is 0.0 for all axes.

The correct value can be determined using the following formula:

ffacc = pgain * error / accel

Where:

pgain = proportional gain (volts / pulse)
error = error at a given acceleration (pulses)
accel = the given acceleration (pulses / second^2)

Note that this formula only applies after the velocity feedforward gain has been set correctly with the FFVEL command. Otherwise, velocity errors will be present as well.

The following example sets X axis acceleration feedforward to 0.000001 volts / pulses / second / second:

Usage example:

```
FFACC X0.000001
```

FFVC (Version 1.18.06 & Up)

Feed Forward Velocity Cutoff Before Target

Format: FFVC { axis { value } } { axis { value } } ...
Group: Servo Control
Units: Pulses

See also: DZL, DZU, DIN, DIP

This command sets the band around the target point, in which the feed forward velocity term is made zero. Issuing a FFVC command to an axis without an argument will display the current setting for that axis. The default value is 0.

The following example sets the X axis FFVC band to 100 pulses.

Usage example:

```
FFVC X 100
```

FIRMWARE (Version 1.18.06 update 14 & up)

Firmware upgrade/backup (Acr8020 only)

Format1: FIRMWARE command
Group: Nonvolatile

This command is used along with a second command to program new firmware into flash memory. The flash memory of Acr8020 was divided into 5 blocks: Bootflash, Sysflash1, Sysflash2, Userflash and Flashslot. Two copies of firmware code are programmed into flash memory at the factory. The Sysfalsh1 area stores the first copy of firmware code and the Sysfalsh2 area stores the second copy of firmware code. The Bootflash area stores the bootloader code, which checks the validity of Sysflash1. If Sysflash1 code is valid, it will be loaded into program RAM at power-up. Otherwise Sysflash2 code will be loaded into program RAM at power-up. The Userflash area stores user programs and parameters by using FLASH commands. Flashslot store system parameters by using ESAVE command.

The following is a list of valid firmware command combinations:

`FIRMWARE UPGRADE`	Program firmware code into the Sysflash1 area
`FIRMWARE BACKUP`	Backup firmware code form Sysflash1 to Sysflash2
`FIRMWARE CHECKSUM`	Calculate firmware checksums

Firmware upgrade/backup (continued)

Related Firmware Flags:

	Mask=0x01
Flag Parameter Code=0x10; Index=0x16	4272

Control Flag	Bit Index	Flag Number
Bootflash Invalid/empty	24	5656
Sysflash1 Invalid/empty	25	5657
Sysflash2 Invalid/empty	26	5658
Userflash Invalid/empty	27	5659
Firmware Backed Up	28	5660
Reserved	29	5661
Reserved	30	5662
Reserved	31	5663

Bootflash Invalid/empty	r	This flag is not valid until the FIRMWARE CHECKSUM command is issued and completed. This flag is cleared if Bootflash code is valid. This flag is set if Bootflash is invalid or empty.
Sysflash1 Invalid/empty	r	This flag is not valid until the FIRMWARE CHECKSUM command is issued and completed. This flag is cleared if Sysflash1 code is valid. This flag is set if Sysflash1 is invalid or empty.
Sysflash2 Invalid/empty	r	This flag is not valid until the FIRMWARE CHECKSUM command is issued and completed. This flag is cleared if Sysflash2 code is valid. This flag is set if Sysflash2 is invalid or empty.
Userflash Invalid/empty	r	This flag is not valid until the FIRMWARE CHECKSUM command is issued and completed. This flag is cleared if Userflash code is valid. This flag is set if Userflash is invalid or empty.
Firmware Backed Up	r	This flag is not valid until the FIRMWARE CHECKSUM command is issued and completed. This flag is cleared if Sysflash1 code and Sysflash2 code is not identical. This flag is set if Sysflash1 code and Sysflash2 code are identical.

r = read, w = write

Firmware upgrade/backup (continued)

Related Firmware Parameters:

Mask	Firmware Information Code=0x1B, Index=0x18		P
0x01	Bootflash Version	LONG	7104
0x02	Bootflash Checksum	LONG	7105
0x04	Reserved	LONG	7106
0x08	Reserved	LONG	7107
0x10	Sysflash1 Version	LONG	7108
0x20	Sysflash1 Checksum	LONG	7109
0x40	Reserved	LONG	7110
0x80	Reserved	LONG	7111

Mask	Firmware Information Code=0x1B, Index=0x19		P
0x01	Sysflash2 Version	LONG	7112
0x02	Sysflash2 Checksum	LONG	7113
0x04	Reserved	LONG	7114
0x08	Reserved	LONG	7115
0x10	Reserved	LONG	7116
0x20	Userflash Checksum	LONG	7117
0x40	Reserved	LONG	7118
0x80	Reserved	LONG	7119

Note: Code, Index, and Mask apply to Binary Communications. Refer to Chapter 6 of this manual.

FIRMWARE UPGRADE (Version 1.18.06 update 14 & up)

Firmware upgrade (Acr8020 only)

Format: Firmware upgrade
Group: Nonvolatile

This command is used to program new firmware into the Sysflash1 area. Issue command FIRMWARE CHECKSUM and verify that the Sysflash2 Invalid/empty flag is cleared before this command is attempted. If the Sysflash2 code is valid and the FIRMWARE UPGRADE process fails, the Acr8020 bootloader can still load Sysflash2 code at power-up. If the Sysflash2 code is invalid and the FIRMWARE UPGRADE process fails, the Acr8020 board needs to be sent back to the factory to be re-programmed. The firmware upgrade procedure is as follows:

1. At SYS prompt type HALT ALL to halt all programs and plc programs.
2. Type CLEAR to clear memory dimension.
3. Make sure all machines controlling by acr8020 are shut down.
4. Type FIRMWARE CHECKSUM and verify flag 5658 is cleared and flag 5660 is set, Otherwise type FIRMWARE BACKUP command to backup firmware first.
5. Type FIRMWARE UPGRADE.
6. At the prompt “Are you sure that you want to upgrade firmware(y/n)?”, answer y.
7. Send Acr8020.dat as a text file. When the file has started loading, the display should read “FIRMWARE UPGRADE START”
8. Wait a few minutes until the display reads “FIRMWARE UPGRADE COMPLETE”. Do not power down or perform any other functions until this operation is completed.
9. Depress the ACR8020 reset switch, SW2, and verify that the green watchdog LED is re-lit and that the communication port works.
10. Type VER and verify that the correct firmware version is running.
11. Type FIRMWARE CHECKSUM and verify that Sysflash1 checksum matches the provided checksum and flag 5657 is set.
12. Type FIRMWARE BACKUP to backup firmware. Do not power down or perform any other functions until this operation is completed.
13. Type FIRMWARE CHECKSUM and verify that Sysflash1 checksum and Sysflash1 checksum are identical, flag 5658 is cleared and flag 5660 is set.

FIRMWARE BACKUP (Version 1.18.06 update 14 & up)

Firmware backup (Acr8020 only)

Format: Firmware backup
Group: Nonvolatile

This command copies firmware code from Sysflash1 to Sysflash2 if the Sysflash1 code is valid. Do not power down or perform any other functions until this operation is completed.

FIRMWARE CHECKSUM (Version 1.18.06 update14 & up)

Calculate firmware checksum (Acr8020 only)

Format: Firmware checksum
Group: Nonvolatile

This command calculates firmware checksum. All the firmware related flags and parameters are not valid until this operation is completed.

FFVEL

Set feedforward velocity

Format: FFVEL { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / pulses / second

See also: FFACC, PGAIN, IGAIN, DGAIN, PPU

This sets the velocity feedforward for an axis. Issuing an FFVEL command to an axis without an argument will display the current setting for that axis. The default velocity feedforward gain is 0.0 for all axes.

The correct value can be determined using the following formula:

ffvel = pgain * error / veloc

Where:

pgain = proportional gain (volts / pulse)
error = error at a given velocity (pulses)
veloc = the given velocity (pulses / second)

Note that this formula will not work correctly if there is any DC offset in the drives. Either adjust the drives, or use the PID integral term to remove the offset first..

The following example sets X axis velocity feedforward to 0.0001 volts / pulses / second:

Usage example:

```
FFVEL X0.0001
```

FLASH (Version 1.17.03 & Up)

User Program Storage

Format: FLASH command
Group: Nonvolatile

See also: PROM ESAVE ELOAD ERASE

This command is used with a second command to manipulate an image of the user memory in the flash onboard the ACR1200, ACR1500, ACR2000, and the ACR8010.

FLASH SAVE stores an image of the user programs and PLC programs in the flash onboard the ACR1200/ACR1500/ACR2000/ACR8010. If the image is detected in the flash on power-up, the card will load user programs and PLC's from flash instead of relying on the battery backup memory. User variables will reside in battery backup memory and will not be affected by the program transfer.

FLASH IMAGE stores an image of the user programs and PLC programs, as well as the User Global Variables, in the flash onboard the ACR1200/ACR1500/ACR2000/ACR8010. If the image is detected in the flash on power-up, the card will load the user programs, PLC's, and user variables from flash instead of relying on the battery backup memory.

WARNING: If a FLASH SAVE or FLASH IMAGE command is performed when there is data present in the flash, a FLASH ERASE will automatically be performed by the CPU and all data previously stored in the flash will be overwritten.

ACR2000 ONLY: For expanded user memory (512Kbytes) on the ACR2000 board, flash storage is limited to 384Kbytes of program, PLC and user variable information.

The following is a list of valid flash command combinations:

`FLASH LOAD`	Load user image from flash
`FLASH SAVE`	Save user program image to flash
`FLASH IMAGE`	Save user variable and program image to flash **(Version 1.17.07 & Up)**
`FLASH ERASE`	Erase user image from flash

The power-up flash load can be bypassed, using the Flash Bypass Mode **(Version 1.17.07 & Up)**. The Flash Bypass Mode is implemented by setting the ACR1200/ACR1500/ACR2000/ACR8010 Card Address Switch (SW1). Refer to the appropriate Hardware Manual for details. When the Flash Bypass Mode is implemented, the user programs, PLC's, and user variables (if a FLASH IMAGE command was used), will not be loaded at power-up or reset and PBOOT commands in battery backup memory will be disabled.

The following example stores the user program image into flash, leaving the user variable in battery backup memory:

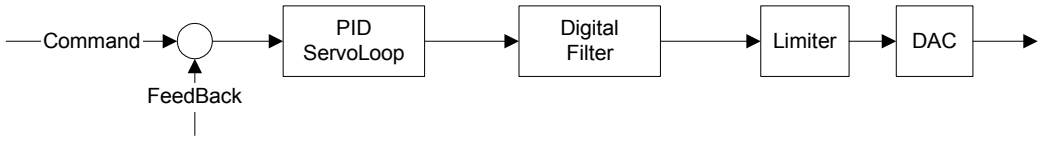
Usage example:

```
FLASH SAVE
```

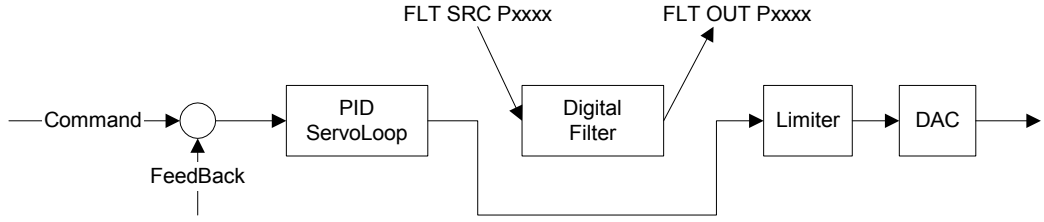
FLT (Version 1.18.06)

Set input and out of the digital filter

This command is used along with a second command to define the input and output of the digital filter in the servo loop. By using this command one can move the servo loop digital filter between any two P parameters. This gives the flexibility of filtering any P parameter on the controller.



FLT OFF



FLT ON

Note:

This filter is still updated in the servo loop block. The sequence in which the input, output and digital filter will update should be carefully sought, so that nothing is overwritten.

FLT SRC (Version 1.18.06)

Set input source of the digital filter

Format: FLT SRC {Parameter**}**
Group: Servo Control
See also: LOPASS , NOTCH, FLT OUT

This command is used to set the input of the digital filter to a specific parameter.

Usage example:

FLT 0 SRC P12280

Current position of the axis 0 becomes the input of the digital filter 0.

FLT OUT (Version 1.18.06)

Set output of the digital filter

Format: FLT OUT {parameter}
Group: Servo Control
See also: LOPASS , NOTCH, FLT SRC

This command is used to set the output of the digital filter to a specific parameter.

Usage example:

```
FLT 0 OUT P8449
```

The output of digital filter 0 goes to vector velocity of master 1.

FLT ON (Version 1.18.06)

Turn on the filter at the new location

Format: FLT ON
Group: Servo Control
See also: LOPASS , NOTCH, FLT SRC

FLT ON command will move the filter between FLT SRC and FLT OUT and start updating every servo loop. It will return an error if the source and output of the filter has not already been assigned.

Usage example:

```
FLT 0 ON
```

FLT OFF (Version 1.18.06)

Put back the filter to its defalut location

Format: FLT OFF
Group: Servo Control
See also: LOPASS , NOTCH, FLT SRC

This command will put back the filter to its default location.

Usage example:

```
FLT 0 OFF
```

FLZ

Relative program path shift

Format: FLZ { axis { shift } } { axis { shift } } ...
Group: Transformation

See also: SCALE, ROTATE, OFFSET

This command will cause the programmed path to be shifted. The amount of the path shift is defined by the "shift" relative to the current location. The program will think that the axis is currently at the location specified by the shift. If the shift for an axis is not specified, the offset will be cleared and any shift will be canceled.

Usage example:

```
10 FLZ X10000 Y20000
```

FOR / TO / STEP / NEXT

Loop execution certain number of times

Format: FOR (counter start value) TO (counter final value) STEP (increment) commands NEXT
Group: Program Flow

For loop is used to execute a loop certain number of times. The three values in the control section of a FOR loop deterimines how many times the loop will be executed. The start values specifies a value at which counting will begin. The final value specifies at which couting will end. The STEP value indicates how much the loop couter will be incremented on each pass of the loop. The BREAK command can be used to break out of the FOR loop if certain condition is met.

Usage example:

```
#DEFINE     Counter     LV0
#DEFINE     Stop        BIT32

PROGRAM
DIM LV2
DWL 5
FOR Counter=0 TO 100 STEP 2
      Print "Counting ",
      Print "Seconds = ", Counter
      IF (Stop)
            Print " Stop Counting"
            BREAK
      ENDIF
      Print " Dwell for 2 sec"
      DWL 2
NEXT

ENDP
```

FOV

Set feedrate override

Format: FOV { rate }
Group: Velocity Profile

See also: VEL, ROV

This command sets the velocity override for the current master. The argument is a floating point scaling factor for the master's velocity profile. Issuing an FOV command without an argument will cause the current feedrate override value to be displayed.

The feedrate override takes place immediately during a feed move (Secondary Master Flag Rapid Active is disabled). If a feed move is in progress, the master will use its ACC or DEC settings to ramp to the new velocity.

The following example will reduce the velocities of feed moves generated by the current master to 75% of their programmed values:

Usage example:

```
FOV 0.75
```

FSTAT (Version 1.18.06)

Fast status setup (ACR8020 only)

Format1: FSTAT {command {data}}
Format2: FSTAT index1 {command}
Format3: FSTAT index1 (Code,Index)
Group: Global Objects

This command is available on the ACR8020 only.

This command allows the system parameters being update to the dual port memory at the servo interrupt rate. The Acr8020 updates the dual port fast status periodically at the end of the servo loop update portion. The dual port fast status update frequency is set by the FSTAT PERIOD command. An interlocking mechanism is provided to prevent data fetching from the PC side while the ACR8020 is in the middle of dual port fast status update operayion.

The following is a list of valid FSTAT command combinations:

Format1:

FSTAT	Display the setting of FSTAT
FSTAT ON	Enable dual port fast status update
FSTAT OFF	Disable dual port fast status update
FSATA CLEAR	Clear the setting of all FSTAT
FSTAT PERIOD period	Set the dual port fast status update frequency

Format2:

FSTAT index1	Display the setting of FSTAT index1

Format3:

FSTAT index1(Code,Index)	Setup FSTAT index1

A total of 10 groups of system parameters can be updated to the dual port memory simultaneously. Each group contains 8 parameters. Please refer to Chapter 6 Binary Data Packets for the selection of Group and Index.

FSTAT (Version 1.18.06)

Fast status setup (ACR8020 only)

Related System Parameters:

Mask	FSTAT Information (Version 1.18 & Up) Code=0x1B; Index=0x12		P
0x01	Fstat Period	LONG	7056
0x02	Fstat Count	LONG	7057

Fstat Period Field Description r/w Set the FSTAT update frequency. This field can also be set by the FSTAT PERIOD command.

Fstat Counter Field Description r Fstat Period is copied to Fstat Counter when FSTAT is turned on or every time the FSTAT update is finished. Fstat counter decreases by 1 every servo interrupt. FSTAT update is performed if Fstat counter is less than or equals to zero.

		Mask	0x01	0x02	0x04	0x08	0x10	0x20	0x40	0x80
	FSTAT Setup Parameters		FSTAT Number							
Index	Code=0x1D		0	1	2	3	4	5	6	7
0x00	Reserved	LONG	7424	7440	7456	7472	7488	7504	7520	7536
0x01	Reserved	LONG	7425	7441	7457	7473	7489	7505	7521	7537
0x02	Reserved	LONG	7426	7442	7458	7474	7490	7506	7522	7538
0x03	Code	LONG	7427	7443	7459	7475	7491	7507	7523	7539
0x04	Index	LONG	7428	7444	7460	7476	7492	7508	7524	7540
0x05	Type	LONG	7429	7445	7461	7477	7493	7509	7525	7541
0x06	Spare	LONG	7430	7446	7462	7478	7494	7510	7526	7542
0x07	Spare	LONG	7431	7447	7463	7479	7495	7511	7527	7543

		Mask	0x01	0x02	0x04	0x08	0x10	0x20	0x40	0x80
	FSTAT Setup Parameters		FSTAT Number							
Index	Code=0x1D		0	1	2	3	4	5	6	7
0x80	Reserved	LONG	7552	7568						
0x81	Reserved	LONG	7553	7569						
0x82	Reserved	LONG	7554	7570						
0x83	Code	LONG	7555	7571						
0x84	Index	LONG	7556	7572						
0x85	Type	LONG	7557	7573						
0x86	Spare	LONG	7558	7574						
0x87	Spare	LONG	7559	7575						

Table1. FSTAT parameters

Fast status setup (ACR8020 only)

Code Field Description	r/w	The group code and group index work as a pair to select the data to be copied to dual port memory. The group code selects a general data grouping and the group index selects a set of eight fields within that group. The group code and group index parameters can be changed while the FSTAT is on and it won't affect the current FSTAT setup. The new FSTAT setup will not be effective until the FSTAT ON REQUEST Flag is acknowledged.
Index Field Description	r/w	The group code and group index work as a pair to select the data to be copied to dual port memory. The group code selects a general data grouping and the group index selects a set of eight fields within that group. The group code and group index parameters can be changed while the FSTAT is on and it won't affect the current FSTAT setup. The new FSTAT setup will not be effective until the FSTAT ON REQUEST Flag is acknowledged.
Type Field Description	r	Data Type: 1 = FP32 2 = LONG

FSTAT (Version 1.18.06)

Fast status setup (ACR8020 only)

Related Flags:

	Mask=0x02
Flag Parameter Code=0x10; Index=0x16	4278

Flag Description	Bit Index	Flag Number
FSTAT ON	0	5824
FSTAT ON REQUEST	1	5825
Spare	2	5826
Spare	3	5827
Spare	4	5828
Spare	5	5829
Spare	6	5830
Spare	7	5831
Spare	8	5832
Spare	9	5833
Spare	10	5834
Spare	11	5835
Spare	12	5836
Spare	13	5837
Spare	14	5838
Spare	15	5839
Spare	16	5840
Spare	17	5841
Spare	18	5842
Spare	19	5843
Spare	20	5844
Spare	21	5845
Spare	22	5846
Spare	23	5847
Spare	24	5848
Spare	25	5849
Spare	26	5850
Spare	27	5851
Spare	28	5852
Spare	29	5853
Spare	30	5854
Spare	31	5855

Note: Code, Index, and Mask apply to Binary Communications. Refer to Chapter 6 of this manual.

Table2. Fstat Flags

fstat flags:

FSTAT ON r/w Flag will be set if the FSTAT is on. Clear this flag will turn off FSTAT. This flag should **NOT** be set directly.

FSTAT ON Request r/w Setting this Flag will update internal FSTAT parameters and turn on FSTAT if FSTAT parameters are set up properly. **Processor acknowledgment clears the FSTAT ON Request Flag.**

FSTAT (Version 1.18.06)

Fast status setup (ACR8020 only)

Example 1 setup the dual port fast status.

Example1

```
REM   Clear FSTAT
fstat clear

REM   Update FSTAT every other servo interrupt
fstat period 2

REM   DPCB Status
fstat0(27,22)
REM   General Flags
fstat1(16,0)
REM   Encoder Position
fstat2(24,0)
REM   Master Distanceinto Move
fstat3(32,0)
REM   Axis Following Error
fstat4(48,3)
REM   Master Vector Velocity
fstat5(32,1)
REM   Primary Set Point
fstat6(48,6)
REM   FOV for Masters
fstat7(32,9)
REM   Program flags
fstat8(16,4)
REM   Program flags
fstat9(16,5)

REM   Turn on FSTAT
fstat on
REM   Display the above setting
fstat
```

FVEL

Set final velocity

Format: FVEL { rate }
Group: Velocity Profile
Units: units / second

See also: VEL, ACC, DEC, STP, IVEL

This command sets the final velocity value for a master move profile. Final velocity is used as a target velocity when the STP ramp is active. The value is used to slow down, but not stop, between moves.

A move will not ramp up to this value, it will only ramp down. The final velocity is only used when STP is non-zero and the current velocity is greater than the final velocity.

Issuing an FVEL command without an argument will display the current setting. The default final velocity is zero. Regardless of the setting, the master bits "FVEL Zero Pending" and "FVEL Zero Active" can be used to temporarily override the final velocity to zero. An error will be returned if no master is attached.

Usage example:

This example generates a path using different combinations of velocity, final velocity, and stop ramps. Note that the velocity profile between moves 3 and 4 does not ramp down even though STP is set to 1000. This is because the final velocity of 2000 is greater than the current velocity at that point in the profile.

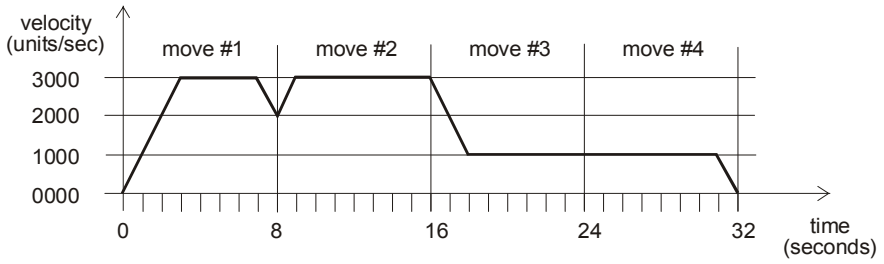


Figure 3.7 Final velocity example

```
10 ACC1000 DEC1000
20 VEL3000 FVEL2000 STP1000 X/19000
30 VEL3000 FVEL2000 STP0 X/23500
40 VEL1000 FVEL2000 STP1000 X/10000
50 VEL1000 FVEL0 STP1000 X/7500
```

GEAR

Electronic gearing

Format: GEAR command axis { data } { axis { data } } ...
Group: Setpoint Control

See also: HDW, CAM, BSC, BKL, JOG

In electronic gearing, pulses are fed from a selected source into the gear offset of a slave axis. These pulses are scaled by a ratio that is equivalent to a gearbox ratio on a mechanical system. The rate at which the ratio changes is controlled by a ramping mechanism similar to a clutch or a variable speed gearbox.

The following is a list of valid electronic gearing command combinations:

`GEAR SRC`	Set electronic gearing source
`GEAR PPU`	Scale electronic gearing input
`GEAR RATIO`	Set electronic gearing ratio
`GEAR ACC`	Set gearing acceleration
`GEAR DEC`	Set gearing deceleration
`GEAR RES`	Reset or preload gearing output
`GEAR ON`	Turn electronic gearing on
`GEAR OFF`	Turn electronic gearing off
`GEAR MIN`	Set minimum gear offset limit
`GEAR MAX`	Set maximum gear offset limit
`GEAR ON TRG`	Enable gear on external trigger
`GEAR OFF TRG`	Disable gear on external trigger

The commands can also be issued using the "handwheel" command, i.e. HDW RATIO. There is only one internal mechanism for electronic gearing so the use of either the HDW or GEAR command depends on programming preference.

GEAR

Electronic gearing (continued)

Block Diagram:

The following block diagram outlines the operation of electronic gearing:

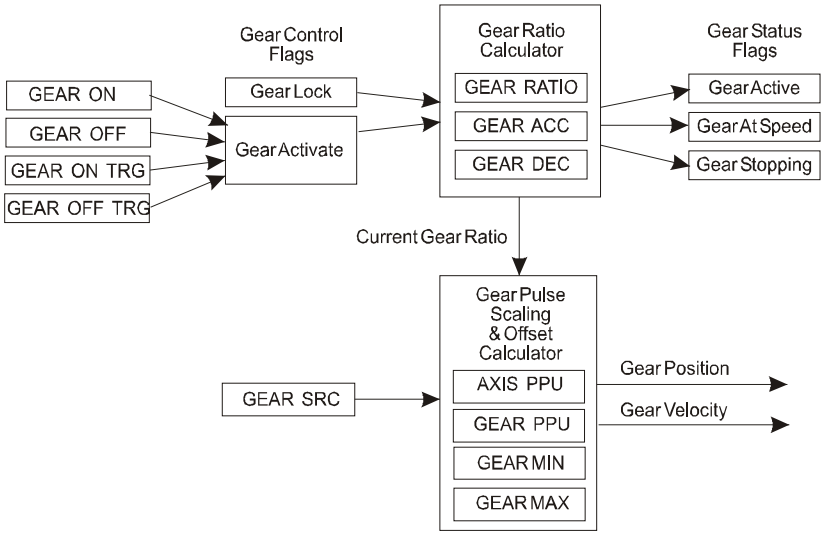


Figure 3.8 Electronic gearing diagram

Usage example:

This example will cause X axis to follow encoder 1 at a 1:4 ratio. Note that the PPU values equate to 0.25 inches per revolution (IPR). The slave axis will move 0.25 inches for every revolution of the electronic gearing source encoder.

```
PPU X10000          : REM Slave is 10000 pulses per inch
GEAR SRC X1         : REM Tie slave's gearbox to ENC1
GEAR PPU X1000      : REM Master is 1000 pulses per rev
GEAR RATIO X.25     : REM Set gear ratio at 1:4 ( 0.25 IPR )
GEAR ON X           : REM Turn electronic gearing on
```

GEAR

Electronic gearing (continued)

Usage example:

This example uses the GEAR ON TRG and GEAR OFF TRG commands to control when the gear is enabled.

NOTE: GEAR ON TRG and GEAR OFF TRG are available in |Firmware Version 1.18.04 & Up.

```
ATTACH MASTER0
ATTACH SLAVE0 AXIS0 "X"
ATTACH SLAVE1 AXIS1 "Y"

GEAR SRC Y0
GEAR RATIO Y1
X/ 200000
GEAR ON Y TRG(2, 0)            Mode 2, Rising Primary External.
OFFSET 3000                    Capture Register 0, gear source is
                               ENC0.
                               Offset is positive, X-axis is
                               moving in positive direction.
INH 2344                       Wait, capture register is shared by
                               GEAR TRG ON and GEAR TRG OFF.
GEAR OFF Y TRG(2,0)            The gear will turn off 6500 pulses
OFFSET 6500                    after the trigger is received.
INH 2348
```

GEAR

Electronic gearing (continued)

Related System Flags:

The following axis flags control and monitor electronic gearing:

Gear Lock	r/w	Overrides the gearing ramp mechanism. Locks the current gear ratio to the target gear ratio regardless of the current gear acc/dec settings.
Gear At Speed	r	Set when gearing is active and the current gear ratio is equal to the target gear ratio. Cleared if executing a gear acc/dec ramp.
Gear Stopping	r	Set when gearing is active and the gear activation bit is clear. When the current gear ratio reaches zero, the gear active bit is cleared.
Gear Activate	r/w	Set and cleared by the gear on/off commands. Can also be set and cleared manually to turn gearing on and off from a PLC or user program.
Gear Active	r	Set when gearing is active. Must inhibit on this bit after a gear off command to check for completion of the gear decel ramp.

r = read, w = write

Gear Flags	AXIS Number							
	0	1	2	3	4	5	6	7
Gear Lock	781	813	845	877	909	941	973	1005
Gear At Speed	782	814	846	878	910	942	974	1006
Gear Stopping	783	815	847	879	911	943	975	1007
Gear Activate	788	820	852	884	916	948	980	1012
Gear Active	789	821	853	885	917	949	981	1013

Issuing just the GEAR command will display the current setting of a gear and can be used even if the gear is currently active. The example below shows the list

Usage example:

```
P00>GEAR Y
GEAR ACC Y0
GEAR DEC Y0
GEAR MAX Y100
GEAR MIN Y-100
GEAR PPU Y1000
GEAR RATIO Y1
GEAR SRC Y ENC 3
GEAR ON Y
```

GEAR CLEAR

CLear electronic gearing settings

Format: **GEAR CLEAR {axis}**
Group: SetPoint control
See also: GEAR

This command will clear the current setting of a gear. It will turn off the gear and then reset the gear variables to their initial default values.

Usage example:

```
GEAR CLEAR X
```

GEAR SRC

Set electronic gearing source

Format: GEAR SRC axis sourcedef { axis sourcedef } ...
Group: Setpoint Control
Units: none

See also: SRC

This command specifies the source for the input of an electronic gearbox. See the SRC command for the definition of the "sourcedef" argument.

The following example connects the X axis gearing to encoder 1, the Y axis to ratchet number 3, and the A axis to the output of PLC counter number 5 (P6743) :

Usage example:

```
GEAR SRC X1 Y RATCH 3
GEAR SRC A P6743
```

GEAR PPU

Set gearing pulses per unit

Format: GEAR PPU axis { ppu } { axis { ppu } } ...
Group: Setpoint Control
Units: input pulses / input unit

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command establishes the relationship between the source encoder and the "input shaft" of the electronic gearbox. The GEAR RATIO command is responsible for setting the ratio between the input and output shafts. Issuing a GEAR PPU command to an axis without an argument will display the current setting for that axis. The default gearing pulses per unit is 1.0 for all axes.

The following example sets up the X axis "input shaft" for 1000 pulses per revolution:

Usage example:

```
GEAR PPU X1000
```

GEAR RATIO

Set electronic gearing ratio

Format: GEAR RATIO axis { ratio } { axis { ratio } } ...
Group: Setpoint Control
Units: output units / input unit

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command sets the ratio between the "input shaft" and the "output shaft" of an electronic gearbox. The "speed" of the output shaft is equal to the speed of the input shaft multiplied by this ratio. Issuing a GEAR RATIO command to an axis without an argument will display the current setting for that axis. The default gearing pulses per unit is 1.0 for all axes.

The following example sets up the Y axis gearbox for a 1:10 ratio:

Usage example:

```
GEAR RATIO Y(1/10)
```

GEAR RES

Reset or preload gearing output

Format: GEAR RES axis { offset } { axis { offset } } ...
Group: Setpoint Control
Units: output units

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command either clears or preloads the gear offset for the given axis. If the "offset" parameter is left out, the gearing offset is set to zero. Otherwise the offset is preloaded to the given value.

The difference between the old offset and the new offset will show up in the axis current position. This prevents the axis from jumping when the gear offset changes.

The following example clears out the gear offset for the Z axis:

Usage example:

```
GEAR RES Z
```

GEAR ACC

Set gearing acceleration

Format: GEAR ACC axis { accel } { axis { accel } } ...
Group: Setpoint Control
Units: output units / input unit / second

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command sets the rate at which the gear ratio will change when the target gear ratio is higher than the current ratio. This will occur both when gearing is turned on and when a higher gear ratio is set with the GEAR RATIO command.

Setting gearing acceleration to 0.0 (default) or setting the "gear lock" flag will cause an immediate lock. Issuing a GEAR ACC command to an axis without an argument will display the current setting for that axis.

NOTE: See Axis Parameter “Gear Slip”.

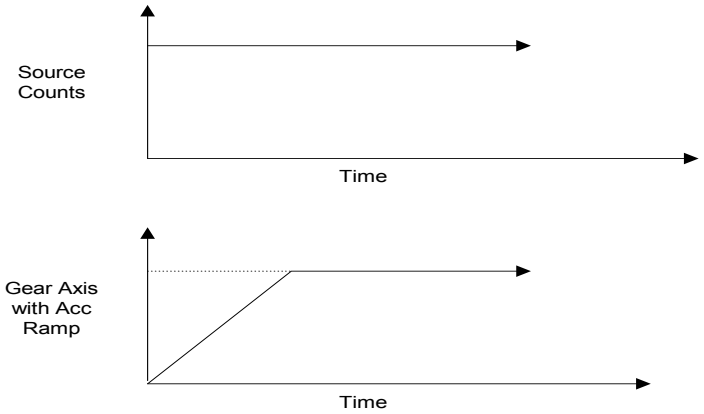
The following example sets the X axis gearing acceleration to 2.

Usage example:

```
GEAR ACC X2
```

GEAR ACC SLIP **(Version 1.18.04)**

When the gear acceleration is not zero, then the geared axis will take some time to ramp up to the velocity of its source. The number of source pulses that are missed before the geared axis is at velocity are stored in the axis parameter “Gear Slip”. This gives the flexibility to recover these missed counts by adding an incremental move to the geared axis by a magnitude of “Gear Slip” value.



GEAR DEC

Set gearing deceleration

Format: GEAR DEC axis { decel } { axis { decel } } ...
Group: Setpoint Control
Units: output units / input unit / second

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command sets the rate at which the gear ratio will change when the target gear ratio is lower than the current ratio. This will occur both when gearing is turned off and when a lower gear ratio is set with the GEAR RATIO command.

Setting gearing deceleration to 0.0 (default) or setting the "gear lock" flag will cause an immediate lock. Issuing a GEAR DEC command to an axis without an argument will display the current setting for that axis.

The following example sets the X axis gearing deceleration to 5.0 :

Usage example:

```
GEAR DEC X5
```

GEAR ON

Turn electronic gearing on

Format: GEAR ON axis { offset } { axis { offset } } ...
Group: Setpoint Control
Units: output units

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command enables electronic gearing for an axis. If the optional "offset" parameter is left out, it is ignored. Otherwise the offset is preloaded to the given value.

The difference between the old offset and the new offset will show up in the axis current position. This prevents the axis from jumping when the gear offset changes.

The following example turns on electronic gearing for axis X, Y and Z. The X axis gear offset is preloaded to 1000.

Usage example:

```
GEAR ON X1000 Y Z
```

GEAR OFF

Turn electronic gearing off

Format: GEAR OFF axis { offset } { axis { offset } } ...
Group: Setpoint Control
Units: output units

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command disables electronic gearing for an axis. If the optional "offset" parameter is left out, it is ignored. Otherwise the offset is preloaded to the given value.

The difference between the old offset and the new offset will show up in the axis current position. This prevents the axis from jumping when the gear offset changes.

The following example disables electronic gearing on the X and Y axis:

Usage example:

```
GEAR OFF X Y
```

GEAR MIN

Set minimum gear offset limit

Format: GEAR MIN axis { value } { axis { value } } ...
Group: Setpoint Control
Units: units

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command sets the minimum gear offset limit for the given axis. The minimum gear offset is defined by the "offset" relative to the current location of the gear source.

Issuing the GEAR MIN command to an axis without an argument displays the minimum limit for that axis. The default is 0.0 for all axis.

The following example sets the offset minimum for the Y axis gear:

Usage example:

```
GEAR MIN Y -1000
```

Secondary Axis Flag "Gear Min" **(Version 1.18.06 Update 09)**
When the gear min limit is hit, this flag is automatically set. It self clears when gear comes back within the min limit.

GEAR MAX

Set maximum gear offset limit

Format: GEAR MAX axis { value } { axis { value } } ...
Group: Setpoint Control
Units: units

See also: GEAR, HDW, CAM, BSC, BKL, JOG

This command sets the maximum gear offset limit for the given axis. The maximum gear offset is defined by the "offset" relative to the current location of the gear source.

Issuing the GEAR MAX command to an axis without an argument displays the maximum limit for that axis. The default is 0.0 for all axis.

The following example sets the offset maximum for the Y axis gear:

Usage example:

```
GEAR MAX Y -1000
```

Secondary Axis Flag "Gear Max" **(Version 1.18.06 Update 09)**
When the gear max limit is hit, this flag is automatically set. It self clears when gear comes back within the max limit.

GEAR ON TRG (Version 1.18.04 & Up)

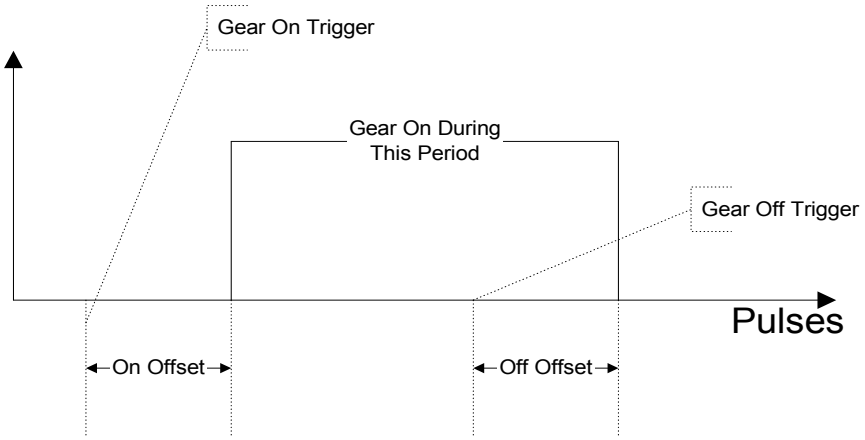
Enable gear on external source trigger

Format: **GEAR ON {axis {offset}} TRG(mode, capture register) OFFSET {value}**
Group: Setpoint Control

This command is not available on the ACR8000.

This command arms the GEAR to begin when an external source trigger occurs. The latency error is 1 microsecond. The mode parameter and hardware capture register information for the GEAR ON TRG is the same as those used in the INTCAP command.

The offset is the number of pulses from the trigger point to where the gear will be turned on. It is stored in the axis parameter " Gear Trigger On Offset". The offset should be positive if the gear source is moving in the positive direction, and vice versa. The default offset value is zero, which will immediately turn on the gear.



Usage example:

```
REM  Gear Source is the actual position of axis0
GEAR SRC Y ENC0
REM ACR8010;
REM Mode = Primary Rising External (INP 24); Cap Register=0
GEAR ON Y  TRG(2,0)
X/90
INH 809  : REM wait for capture complete.
REM Mode = Primary Rising Marker; Capture Register=1
GEAR OFF Y TRG(0,1)
```

GEAR ON TRGP (Version 1.18.06 Update 09)

Enable gear on external trigger

Format: **GEAR ON {axis {offset}} TRGP(mode, capture register) OFFSET {value}**
Group: Setpoint Control

This command is not available on the ACR8000.

This command is same as the GEAR ON TRG, except that gear can be triggered from any P parameter. In this case the capture register value is not used since it is different from the gear source value. Thus resulting in a less precise response than when triggered from the gear source. The worse case latency error could be up to one servo period.

Usage example:

```
REM  Gear Source is the current position of axis0
GEAR SRC Y P12288
REM ACR8010;
REM Mode = Primary Rising External ( INP 24); Cap Register = 0
GEAR ON Y  TRGP(2,0)
X/90
INH 809  : REM wait for capture complete.
GEAR OFF Y
```

GEAR OFF TRG (Version 1.18.04)

Gear off by external source trigger

Format: **GEAR OFF {axis} TRG(mode, capture register) OFFSET {value}**
Group: Setpoint Control

This command is not available on the ACR8000.

This command arms the GEAR to stop when an externally sourced trigger occurs. The latency error is 1 microsecond. The mode parameter and hardware capture register information for the GEAR ON TRG is the same as those used in the INTCAP command.

The offset is the number of pulses from the trigger point to where the gear will be turned off. It is stored in the axis parameter " Gear Trigger Off Offset". The offset should be a positive number if the gear source is moving in the positive direction, and vice versa. The default offset value is zero, which will immediately turn off the gear.

Usage example:

```
GEAR SRC Y ENC0
:
REM Mode = Primary Rising Marker; Capture Register = 1
GEAR OFF Y TRG(0,1)
```

GEAR OFF TRGP (Version 1.18.06 Update 09)

Gear off by external trigger

Format: **GEAR OFF {axis} TRG(mode, capture register) OFFSET {value}**
Group: Setpoint Control

This command is not available on the ACR8000.

This command is same as the GEAR OFF TRG, except that gear can be triggered from any P parameter. In this case the capture register value is not used, since it is different from the gear source value. Thus resulting in a less precise response than when triggered from the gear source. The worse case latency error could be up to one servo period.

Usage example:

```
GEAR SRC Y P12288
:
REM Mode = Primary Rising Marker; Capture Register = 1
GEAR OFF Y TRGP(0,1)
```

GOSUB

Branch to a subroutine

Format: GOSUB line
Group: Program Flow

See also: RETURN, GOTO

This command causes an unconditional branch to a subroutine. Each subroutine call requires 4 bytes of free memory to store its return address. Each subroutine must be terminated with a RETURN command

Usage example:

```
100 REM --- main program loop
110 INH 0 : INH -0
120 IF (BIT1) THEN GOSUB 200 : GOTO 110
130 IF (BIT2) THEN GOSUB 300 : GOTO 110
140 GOTO 110
200 REM --- first subroutine
210 X10000
220 X0
230 INH -516 : REM not in motion
240 RETURN
300 REM --- second subroutine
310 X5000
320 X2500
330 X10000
340 X0
350 INH -516 : REM not in motion
360 RETURN
```

GOSUB function **(1.18.07 and Up)**

The new lineless Acro-Basic language has the provision for subroutine names, see the following example

Usage example:

```
PROGRAM
_Start
GOSUB ShowMessage
DWL 1
GOTO _Start

_ShowMessage
PRINT " Subroutine DEMO"
RETURN

ENDP
```

Note

DIM DEF command must be used to tell the board that the new Acro-Basic language format is being used.

GOTO

Branch to a new line number

Format: GOTO line
Group: Program Flow

See also: GOSUB, RETURN

The command causes an unconditional branch to occur.

Usage example:

```
10 ACC 0 DEC0 STP0
20 SET 32
30 X/1
40 INH -768
50 CLR 32
60 DWL 2
70 GOTO 20
```

GOTO LABEL **(1.18.07 and Up)**

The new lineless Acro-Basic language has the provision for labels, see the following example

Usage example:

```
PROGRAM
_Start
PRINT " GOTO LABEL DEMO"
DWL 1
GOTO _Start
ENDP
```

Note

DIM DEF command must be used to tell the board that the new Acro-Basic language format is being used.

HALT

Halt an executing program

Format: HALT { PROG number | PLC number | ALL }
Group: Program Control

See also: RUN, LRUN, LISTEN

This command stops the execution of a running program and kills any motion profile initiated by the program. A message is displayed indicating the current line number that was being executed when the program was halted. The HALT command cannot be issued from within a program, use the END command instead.

The optional HALT formats can be issued from anywhere, including programs. The HALT PROG and HALT PLC commands will halt the corresponding user or PLC program. The HALT ALL command will halt all user and PLC programs.

Usage example:

```
HALT
```

HDW

Handwheel

Format: HDW command { axis { data } } { axis { data } } ...
Group: Setpoint Control

See also: GEAR, CAM, BSC, BKL, JOG

Handwheel is another name for the GEAR command used for electronic gearing. See description of GEAR command for details.

HELP

Display command list

Format: HELP
Group: Operating System

This command displays the executive version and command set. The HELP command cannot be issued from within a program.

Usage example:

```
HELP
```

HSINT (Version 1.16.09 & Up)

High-speed Interruptible Move

Format: HSINT axis (mode, target, incmove { , window { , wstart { , abortbit } } }) {CAP capture_register}

Group: Feedback Control

See also: INTCAP, INT, MSEEK, IHPOS

This command initiates a high-speed interruptible move. The HSINT sequence consists of an incremental or absolute move with a capture window in the middle of it. Within the capture window, an internal INTCAP is initiated and monitored. If a capture occurs within the window, the current move is killed and a second move is started.

The mode parameter and hardware capture register are the same as those used in the INTCAP command. Refer to the INTCAP command for mode parameter and hardware capture register selection.

The components of the HSINT command are as follows:

The “axis” designator can be either incremental (trailing forward slash) or absolute. A master can only execute an HSINT command for a single axis at a time.

The “target” parameter is used to start the incremental or absolute move indicated by the axis designator. This move drives the rest of the HSINT sequence.

The “mode” parameter is the same as the mode in the INTCAP command and is used to start looking for a hardware capture in the capture window.

The “incmove” parameter is added to the capture position if a hardware capture is detected within the capture window. In this case, the axis “HSINT Registered” flag is set, the move in progress is killed, and this new value is used as an absolute target position for the rest of the HSINT sequence.

The optional “window” parameter defines the width of the capture window. If this parameter is not present or is zero, the capture window is then defined as the area between the start of the window and the end of the move.

The optional “wstart” parameter defines the start of the capture window. If this parameter is not present, the window begins at the start of the move.

The optional “abortbit” parameter is a flag that is monitored during the entire HSINT sequence. If the bit is seen, the current move is killed and the axis “HSINT Aborted” flag is set indicating a user abort condition.

The “capture_register” is the same as the hardware capture register in the INTCAP command.

Program flow will continue to the next line/command after the “incmov” begins or after the end of the capture window has been passed. If, however, the “abortbit” is being monitored, program flow will continue only after the original move ends, the “incmov” ends, or the entire sequence is aborted.

High-speed Interruptible Move (continued)

Operation Sequence:

The following figure outlines the HSINT operating sequence:

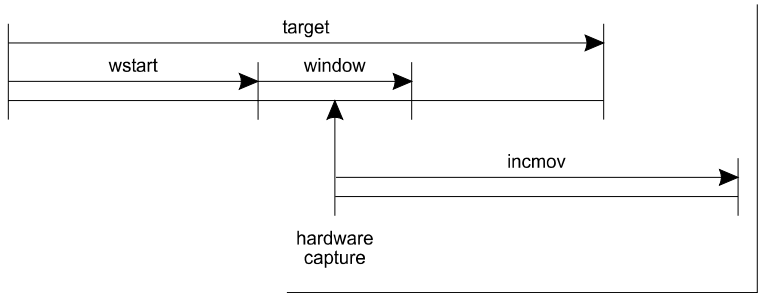


Figure 3.8a HSINT Operation Sequence

Related System Flags:

The following axis flags monitor HSINT results:

HSINT Registered	r	Cleared by the start of the HSINT command. Set when a hardware capture is detected within the HSINT capture window and the “incmov” starts.
HSINT Aborted	r	Cleared by the start of the HSINT command. Set when the optional HSINT “abortbit” is detected and the sequence is aborted.

r = read, w = write

HSINT Flags	AXIS Number							
	0	1	2	3	4	5	6	7
HSINT Registered	778	810	842	874	906	938	970	1002
HSINT Aborted	779	811	843	875	907	939	971	1003

High-speed Interruptible Move (continued)

The following examples assume ENC2 as position feedback on Axis0 (X) as follows:

ATTACH AXIS0 ENC2 DAC0 ADC0

The HSINT command starts an incremental HSINT sequence with a rising primary external capture input, a total move distance of 100000 units, a move after capture of 50000 units, a capture window with a width 20000 units starting 10000 units into the move, and monitoring input 9 for an external abort signal.

Usage example1:

```
100 HSINT X/(2,100000,50000,20000,10000,9)
```

Usage example2: (version 1.18 00)

```
100 HSINT X/(2,100000,50000,20000,10000,9) CAP0
```

HSINT with stepper (version 1.18 06)

Here is the procedure that needs to be followed for using HSINT command with stepper.

- Attach the axis with encoder feedback and stepper output.
- Set the secondary axis flag " Encoder Bypass Servo Lopp".
- The stepper and encoder should have one to one ratio.

Usage example:

```
ATTACH AXIS0 ENC0 STEPPER0 NONE
SET 2327 : REM Encoder Bypass Servo Loop
```

INT Response Period (version 1.18 04)

When the hardware capture occurs and the second move is started immediately, then there may be a small glitch in the motion since there is a finite time required to load the second incremental move. Master parameter " INT Response Period" is added to avoid this scenario. This does not try to start the second move immediately. Rather the current move is extrapolated, while the second move is loaded into the buffer. Then after the INT Response Period, the moves are switched atomically and there is no glitch in motion. The draw back of this method is that it extrapolates the current move and will work well only when the master is at constant steady velocity when the capture occurs. If the contact velocity can't be guaranteed then this feature should not be used by setting the INT Response Period to –1. The default value for the INT Response period is 5 (the units are in servo period).

IDELAY

Set integral time-out delay

Format: IDELAY { axis { value } } { axis { value } } ...
Group: Servo Control
Units: seconds

See also: IGAIN, ILIMIT

This command modifies the value used in the PID algorithm to control integral delay. The integral delay determines the amount of time, after a move ends, before integration begins. If the value is set to zero, integration is active all the time, even during moves.

Issuing an IDELAY command to an axis without an argument will display the current setting for that axis. The default gain is 0.0 for all axes.

The following example sets the X axis integral time-out delay to 100 milliseconds:

Usage example:

```
IDELAY X0.1
```

IF / THEN

Conditional execution

Format: IF (boolean) THEN command
Group: Program Flow

This command is used for conditional branching. If the boolean expression is true, then the rest of the line is executed. Otherwise, the program drops down to the next line. The boolean can either be an expression composed of several variables or a single bit reference.

The following example will set output 32 if input number 10 is active:

Usage example:

```
10 IF (BIT 10) THEN SET 32
```

IF / ELSE IF / ELSE / ENDIF

Conditional execution

Format: IF (boolean) commands ELSE IF (boolean) commands ELSE commands ENDIF
Group: Program Flow

This command is used for conditional branching. If the boolean expression is true, then the following group of statements are executed. Otherwise, the program drops down to check the next Boolean expression . The boolean can either be an expression composed of several variables or a single bit reference.

The following example will count up if bit 32 is set, else if bit 33 is set it will count down. In case neither bit is set then it sets the counter to zero.

Usage example:

```
SYS
DIM PROG0(5000)
DIM DEF(10)

PROG0
#DEFINE     Counter     LV0
#DEFINE     upcount     BIT32
#DEFINE     downcount   BIT33

PROGRAM
DIM LV2
_start
DWL 5
IF (upcount)
      Counter = counter+1
      Print "Counting Up"
      Print "Counter = ", Counter
ELSE IF (downcount)
      Counter = counter-1
      Print "Counting Down"
      Print "Counter = ", Counter
ELSE
      Counter = 0
      Print "Initializing"
      Print "Counter = ", Counter

ENDIF
GOTO start
ENDP
```

IGAIN

Set integral gain

Format: IGAIN { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / second / pulse

See also: IDELAY, ILIMIT, PGAIN, DGAIN, FFVEL, FFACC

This command modifies the value used in the PID algorithm to control integral gain. Issuing an IGAIN command to an axis without an argument will display the current setting for that axis. The default gain is 0.0 for all axes.

To reset the integral term component of the PID algorithm to zero:

- Turn IGAIN on by setting to a number other than zero;
- Set ILIMIT to zero;
- Set IGAIN to zero.

The following example sets the X axis integral gain to 0.1 volts / second / pulse:

Usage example:

```
IGAIN X0.1
```

Note:

If ILIMIT is zero than the integral will remain off, even if the IGAIN value is set to other than zero.

IHPOS

Inhibit on position

Format 1: IHPOS + parameter (setpoint, timeout)
Format 2: IHPOS - parameter (setpoint, timeout)
Group: Logic Function

See also: SET, CLR, INH

This command causes the program to inhibit (suspend) further program execution until the specified parameter passes the given 'setpoint'. Although typically used to inhibit on axis position, this command can watch any system or user defined parameter.

The 'timeout' parameter sets a maximum time, in seconds, to wait for the condition to be met. If the condition is not met within this time limit, the program sets it's timeout flag and continues normally. If the timeout is zero, there is no timeout checking done.

Issuing an IHPOS followed by a plus sign will inhibit until the parameter is greater than or equal to the setpoint. The minus sign will inhibit until the parameter is less than or equal to the setpoint. The plus sign is optional.

The following example will inhibit until the position of ENC0 (P6144) is less than or equal to 10000 pulses, or 1.5 seconds have elapsed :

Usage example:

```
10 IHPOS -P6144(10000,1.5)
```

ILIMIT

Set integral anti-windup limit

Format: ILIMIT { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts

See also: IGAIN, IDELAY

This command modifies the value used by the PID filter to limit the amount of integral term allowed to build up in the loop. Issuing an ILIMIT command to an axis without an argument will display the current setting for that axis. The default limit is 0.0 for all axes.

The following example sets the X axis integration limit to 0.5 volts:

Usage example:

```
ILIMIT X0.5
```

Note:
The ILIMIT should be set to a value other than zero for the integrator to become operational.

INH

Inhibit on a bit high or low

Format 1: INH + index
Format 2: INH - index
Group: Logic Function

See also: SET, CLR

This command cause the program to inhibit (suspend) further program execution until the specified bit is in the selected state. Either the on or off state can be selected. A minus sign preceding the bit number selects the off state. A plus sign is not required.

The following example will inhibit until output 32 becomes de-energized:

Usage example:

```
10 INH -32
```

INPUT

Receive data from a device

Format: INPUT { ; } { #device , } { "prompt string" separator } parameterlist
Group: Character I/O

See also: PRINT, OPEN, CLOSE

This command receives data from a device and places the data into the designated parameters. If no device number is given, device #0 is used. If the device is closed, or was never opened, the INPUT command will return an error.

The optional semicolon that follows the INPUT command controls the echo of characters as they are received. Characters are normally echoed. Placing a semicolon after the command will prevent the characters from being echoed.

If a "prompt string" is used, it will be printed out to the device before the parameters are read from the device. The separator after the prompt string can be either a comma or a semicolon. If the separator is a semicolon, the final carriage return / linefeed output sequence will be suppressed. Otherwise, a carriage return / linefeed will be output after all of the data has been read from the device.

The "parameterlist" is a list of parameters separated with commas. When the data is read from the device, either a comma or a carriage return will cause the current field to be registered and the next field to begin. If the current field is the last parameter in the parameter list, the input command will end.

Characters less than CHR$(32) or greater than CHR$(126) will be ignored. In order to read these characters, the INKEY$ function must be used.

Usage example:

```
100 REM --- main program
110 DIM $V(1,80)
120 OPEN "COM1:9600,N,8,1" AS #1
130 PRINT #1,
140 PRINT #1, "Enter 'EXIT' to quit ..."
200 INPUT #1, "Command?", $V0
210 $V0 = UCASE$($V0)
220 PRINT #1, "["; $V0; "]"
230 IF ($V0 = "EXIT") GOTO 300
240 GOTO 200
300 REM --- program shutdown
310 PRINT #1, "Program terminated"
320 CLOSE #1
```

INT

Interruptible move

Format1: INT + index { axis (target, incmov) } { axis (target, incmov) } ...
Format2: INT - index { axis (target, incmov) } { axis (target, incmov) } ...
Group: Interpolation
Units: units

See also: TRJ, SINE, PPU, MOV

This command initiates an interruptible linear move. The 'index' parameter designates an inhibit bit identical to the INH command. If the bit condition is met before the move ends, the incremental move is immediately executed from that point. Otherwise, the move will complete normally.

The following example starts a move toward X100000. If OUT32 goes away before the move completes, the axis will come to a stop 2000 pulses away from where the trigger condition was met.

Usage example:

```
10 INT -32 X(100000,2000)
```

INT Response Period (version 1.18 04)

When the hardware capture occurs and the second move is started immediately, then there may be a small glitch in the motion since there is a finite time required to load the second incremental move. Master parameter " INT Response Period" is added to avoid this scenario. This does not try to start the second move immediately. Rather the current move is extrapolated, while the second move is loaded into the buffer. Then after the INT Response Period, the moves are switched atomically and there is no glitch in motion. The draw back of this method is that it extrapolates the current move and will work well only when the master is at constant steady velocity when the capture occurs. If the contact velocity can't be guaranteed then this feature should not be used by setting the INT Response Period to –1.The default value for the INT Response period is 5 (the units are in servo period).

INTCAP

Encoder capture

Format: INTCAP { axis mode { capture_register capture_parameter}} { axis mode { capture_register capture_parameter}} ...

Group: Feedback Control

This command enables hardware position capture triggered from one of several different sources. The latency on the capture is less than 100 nanoseconds (1 microsecond delay for external input signals coming through the optoisolators.)

ACR8010:
For each hardware capture register, their are eighteen different capture sources, one of ten markers or one of eight external inputs. Both the rising and falling edges can be selected. After the mode is set up, the next capture trigger causes the hardware to latch the encoder count of the position feedback encoder of the axis and set an interrupt. Then an interrupt handler transfers the capture positions into the "hardware capture" parameters and sets the appropriate "capture complete" flag. If the hardware capture register is not specified, then the hardware capture register index is assumed to be the same as the position feedback encoder index.

ACR8000:
For each encoder, their are four different capture sources, one of two markers or one of two external inputs. Both the rising and falling edges can be selected. After the mode is set up, the next capture trigger causes the hardware to latch the encoder count and set an interrupt. Then an interrupt handler transfers the capture positions into the "hardware capture" parameters and sets the appropriate "capture complete" flag. The hardware capture register index is the same as the feedback encoder index.

ACR1500 and ACR2000:
For each hardware capture register, their are eight different capture sources, one of four markers or one of four external inputs. Both the rising and falling edges can be selected. After the mode is set up, the next capture trigger causes the hardware to latch the encoder count of the position feedback encoder of the axis and set an interrupt. Then an interrupt handler transfers the capture positions into the "hardware capture" parameters and sets the appropriate "capture complete" flag. In firmware version 1.18.00 and above the hardware capture register can be specified. If the hardware capture register is not specified then the hardware capture register index is assumed to be the same as the position feedback encoder index.

Note:

If an Expansion I/O board is present, and the CONFIG IO and CONFIG XIO commands are used to redirect the I/O bits, the hardware capture external sources remain as the appropriate input bit hardware positions on the main boards. (i.e. If an ACR2000 and Expansion I/O board are present, and the CONFIG IO and CONFIG XIO commands are used to redirect the I/O bits, the hardware capture external sources remain as input bit positions 12, 13, 14, and 15 on the ACR2000 mother board.)

INTCAP

Encoder capture

ACR1200:
For each hardware capture register, their are six different capture sources, one of three markers or one of three external inputs. Both the rising and falling edges can be selected. After the mode is set up, the next capture trigger causes the hardware to latch the encoder count of the position feedback encoder of the axis and set an interrupt. Then an interrupt handler transfers the capture positions into the "hardware capture" parameters and sets the appropriate "capture complete" flag. In firmware version 1.18.00 and above the hardware capture register can be specified. If the hardware capture register is not specified then the hardware capture register index is assumed to be the same as the position feedback encoder index.

ACR1200, ACR1500, ACR2000, ACR8000 and ACR8010:
It is also possible to initiate an encoder capture sequence through software. This is done by issuing a SET113 command. This captures all of the encoder positions and transfers them into their "software capture" parameters.

Valid Interrupt Sources Modes:

ACR1200, ACR1500, ACR2000, ACR8000 and ACR8010:

0	Rising Primary Marker
1	Rising Secondary Marker
2	Rising Primary External
3	Rising Secondary External
4	Falling Primary Marker
5	Falling Secondary Marker
6	Falling Primary External
7	Falling Secondary External

ACR1200, ACR1500, ACR2000 and ACR8010 only:

8	Rising Tertiary Marker
9	Rising Fourth Marker
10	Rising Tertiary External
11	Rising Fourth External
12	Falling Tertiary Marker
13	Falling Fourth Marker
14	Falling Tertiary External
15	Falling Fourth External

INTCAP

Encoder Capture, continued

Valid Interrupt Sources Modes (continued):

ACR8010 only :

16	Rising Fifth Marker
17	Rising Sixth Marker
18	Rising Fifth External
19	Rising Sixth External
20	Falling Fifth Marker
21	Falling Sixth Marker
22	Falling Fifth External
23	Falling Sixth External
24	Rising Seventh Marker
25	Rising Eighth Marker
26	Rising Seventh External
27	Rising Eighth External
28	Falling Seventh Marker
29	Falling Eighth Marker
30	Falling Seventh External
31	Falling Eighth External
32	Rising Ninth Marker
33	Rising Tenth Marker
36	Falling Ninth Marker
37	Falling Tenth Marker

Valid choices of capture registers: (ACR1200)

1. Capture register 0~2 for encoder 0~2

Valid choices of capture registers: (ACR1500/ACR2000 Version 1.18 & Up)

1. Capture register 0~3 for encoder 0~3

Valid choices of capture registers: (ACR8010)

1. Capture register 0~3 for encoder 0~3 and encoder 8
2. Capture register 4~7 for encoder 4~7 and encoder 9

INTCAP

Encoder capture (continued)

ACR8000 Interrupt Sources:

Encoder	Primary Marker	Secondary Marker	Primary External	Secondary External
0	MRK 0	MRK 1	INP 24	INP 25
1	MRK 1	MRK 0	INP 25	INP 24
2	MRK 2	MRK 3	INP 26	INP 27
3	MRK 3	MRK 2	INP 27	INP 26
4	MRK 4	MRK 5	INP 28	INP 29
5	MRK 5	MRK 4	INP 29	INP 28
6	MRK 6	MRK 7	INP 30	INP 31
7	MRK 7	MRK 6	INP 31	INP 30

Table 3.10a ACR8000 Hardware Capture Interrupt Sources

ACR8000 Capture Complete Flags/Hardware Capture Parameters:

Axis	Capture Complete Bit Flag	Hardware Capture Parameter
0	777	12292
1	809	12548
2	841	12804
3	873	13060
4	905	13316
5	937	13572
6	969	13828
7	1001	14084

Table 3.10b ACR8000 Hardware Capture Flags/Parameters

INTCAP

Encoder capture (continued)

ACR2000 Interrupt Sources:

Capture Register	Primary Marker	Secondary Marker	Tertiary Marker	Fourth Marker	Primary External	Secondary External	Tertiary External	Fourth External
0	MRK 0	MRK 1	MRK 2	MRK 3	INP 12	INP 13	INP 14	INP 15
1	MRK 1	MRK 0	MRK 3	MRK 2	INP 13	INP 12	INP 15	INP 14
2	MRK 2	MRK 3	MRK 0	MRK 1	INP 14	INP 15	INP 12	INP 13
3	MRK 3	MRK 2	MRK 1	MRK 0	INP 15	INP 14	INP 13	INP 12

Table 3.10c ACR2000 Hardware Capture Interrupt Sources

ACR2000 Default Capture Complete Flags/Hardware Capture Parameters:

Axis	Capture Complete Bit Flag	Hardware Capture Parameter
0	777	12292
1	809	12548
2	841	12804
3	873	13060

Table 3.10d ACR2000 Default Hardware Capture Flags/Parameters

ACR8010 Interrupt Sources:

Capture Register	Primary Marker	Secondary Marker	Tertiary Marker	Fourth Marker	Fifth Marker	Sixth Marker	Seventh Marker	Eighth Marker	Ninth Marker	Tenth Marker
0	MRK 0	MRK 1	MRK 2	MRK 3	MRK 4	MRK 5	MRK 6	MRK 7	MRK 8	MRK 9
1	MRK 1	MRK 0	MRK 3	MRK 2	MRK 5	MRK 4	MRK 7	MRK 6	MRK 9	MRK 8
2	MRK 2	MRK 3	MRK 0	MRK 1	MRK 6	MRK 7	MRK 4	MRK 5	MRK 8	MRK 9
3	MRK 3	MRK 2	MRK 1	MRK 0	MRK 7	MRK 6	MRK 5	MRK 4	MRK 9	MRK 8
4	MRK 4	MRK 5	MRK 6	MRK 7	MRK 0	MRK 1	MRK 2	MRK 3	MRK 8	MRK 9
5	MRK 5	MRK 4	MRK 7	MRK 6	MRK 1	MRK 0	MRK 3	MRK 2	MRK 9	MRK 8
6	MRK 6	MRK 7	MRK 4	MRK 5	MRK 2	MRK 3	MRK 0	MRK 1	MRK 8	MRK 9
7	MRK 7	MRK 6	MRK 5	MRK 4	MRK 3	MRK 2	MRK 1	MRK 0	MRK 9	MRK 8

Capture Register	Primary External	Secondary External	Tertiary External	Fourth External	Fifth External	Sixth External	Seventh External	Eighth External
0	INP 24	INP 25	INP 26	INP 27	INP 28	INP 29	INP 30	INP 31
1	INP 25	INP 24	INP 27	INP 26	INP 29	INP 28	INP 31	INP 30
2	INP 26	INP 27	INP 24	INP 25	INP 30	INP 31	INP 28	INP 29
3	INP 27	INP 26	INP 25	INP 24	INP 31	INP 30	INP 29	INP 28
4	INP 28	INP 29	INP 30	INP 31	INP 24	INP 25	INP 26	INP 27
5	INP 29	INP 28	INP 31	INP 30	INP 25	INP 24	INP 27	INP 26
6	INP 30	INP 31	INP 28	INP 29	INP 26	INP 27	INP 24	INP 25
7	INP 31	INP 30	INP 29	INP 28	INP 27	INP 26	INP 25	INP 24

Table 3.10e ACR8010 Hardware Capture Interrupt Sources

ACR8010 Default Capture Complete Flags/Hardware Capture Parameters:

Axis	Capture Complete Bit Flag	Hardware Capture Parameter
0	777	12292
1	809	12548
2	841	12804
3	873	13060
4	905	13316
5	937	13572
6	969	13828
7	1001	14084

Table 3.10f ACR8010 Default Hardware Capture Flags/Parameters

INTCAP

Encoder capture (continued)

ACR1200 Interrupt Sources:

Capture Register	Primary Marker	Secondary Marker	Tertiary Marker	Fourth Marker	Primary External	Secondary External	Tertiary External	Fourth External
0	MRK 0	MRK 1	MRK 2	N/A	INP 12	INP 13	INP 14	N/A
1	MRK 1	MRK 0	N/A	MRK 2	INP 13	INP 12	N/A	INP 14
2	MRK 2	N/A	MRK 0	MRK 1	INP 14	N/A	INP 12	INP 13
3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.10g ACR1200 Hardware Capture Interrupt Sources

ACR1200 Default Capture Complete Flags/Hardware Capture Parameters:

Axis	Capture Complete Bit Flag	Hardware Capture Parameter
0	777	12292
1	809	12548
2	841	12804

Table 3.10h ACR1200 Default Hardware Capture Flags/Parameters

ACR1500 Interrupt Sources:

Capture Register	Primary Marker	Secondary Marker	Tertiary Marker	Fourth Marker	Primary External	Secondary External	Tertiary External	Fourth External
0	MRK 0	MRK 1	MRK 2	MRK 3	I/O-0	I/O-1	I/O-2	I/O-3
1	MRK 1	MRK 0	MRK 3	MRK 2	I/O-1	I/O-0	I/O-3	I/O-2
2	MRK 2	MRK 3	MRK 0	MRK 1	I/O-2	I/O-3	I/O-0	I/O-1
3	MRK 3	MRK 2	MRK 1	MRK 0	I/O-3	I/O-2	I/O-1	I/O-0

NOTE: The ACR1500 External Interrupt Sources (I/O-0 thru I/O-3) are either inputs to the board or outputs from the board based on the board IO configuration. This is set by the user via the CONFIG IO MODE command. This is available only on the ACR1500.

Table 3.10i ACR1500 Hardware Capture Interrupt Sources

ACR1500 Default Capture Complete Flags/Hardware Capture Parameters:

Axis	Capture Complete Bit Flag	Hardware Capture Parameter
0	777	12292
1	809	12548
2	841	12804
3	873	13060

Table 3.10j ACR1500 Default Hardware Capture Flags/Parameters

INTCAP

Encoder capture (continued)

The Valid Interrupt Source Mode is selected based on the desired interrupt source used for the hardware capture. The interrupt sources for each capture register are shown in Table 3.10a for the ACR8000, Table 3.10c for the ACR2000, Table 3.10e for the ACR8010, Table 3.10g for the ACR1200, and Table 3.10i for the ACR1500.

ACR8000 (all firmware versions)
ACR2000 with version 1.17.08 and below (or Encoder FPGA Rev –01 or –02):
The hardware capture register index is the same as the feedback encoder index of the axis used to enable the hardware capture.

The capture complete flag and hardware capture parameter to be used for the encoder capture is selected based on the axis used to enable the hardware capture. The capture complete flags and hardware capture parameters are shown in tables 3.10b for the ACR8000 and 3.10d for the ACR2000.

ACR1200, ACR1500, and ACR8010 (all firmware versions)
ACR2000 with version 1.18 and above (and Encoder FPGA Rev –03 and above):

The ACR1200/ACR1500/ACR2000/ACR8010 boards have updated encoder input FPGA's that allow multiple sources of data into each hardware capture register. This means that the user will be able to perform multiple captures, using different interrupt sources, on encoder inputs.

Available Hardware Capture Registers for Selection:

ACR1200:	Capture Registers 0 thru 2
ACR1500:	Capture Registers 0 thru 3
ACR2000:	Capture Registers 0 thru 3
ACR8010:	Capture Registers 0 thru 3 for Encoders 0 thru 3, and 8
	Capture Registers 4 thru 7 for Encoders 4 thru 7, and 9

If the feedback encoder is Encoder 8 or 9, the hardware capture register must be specified (ACR8010 only).

If the hardware capture register is not specified, the hardware capture register index is the same as the feedback encoder index of the axis used to enable the hardware capture. The capture complete flag and hardware capture parameter to be used for the encoder capture is selected based on the axis used to enable the hardware capture. The capture complete flags and hardware capture parameters are shown in Table 3.10d for the ACR2000, Table 3.10f for the ACR8010, Table 3.10h for the ACR1200, and Table 3.10j for the ACR1500.

If the hardware capture register is specified then the capture parameter must also be specified. The capture complete flags and hardware capture parameters are still in pairs as shown in Table 3.10d for the ACR2000, Table 3.10f for the ACR8010, Table 3.10h for the ACR1200, and Table 3.10j for the ACR1500, but they are not based on the axis used to enable the hardware capture.

INTCAP

Encoder capture (continued)

Usage example1:

This example uses the INTCAP command as defined for the ACR8000 board.

This example also uses the INTCAP command without defining any hardware capture register for the ACR1200/ACR1500/ACR2000/ACR8010 boards. Using the INTCAP command in this way, the hardware capture register index is the same as the feedback encoder index of the axis used to enable the hardware capture – just like the ACR8000 INTCAP operation. I.E. *ENC2* is used as feedback, therefore use *Hardware Capture Register 2*.

Example1 assumes ENC2 as position feedback on AXIS0 (X) as follows:

```
ATTACH AXIS0 ENC2 DAC0 ADC0
```

In the following program, the INTCAP mode is enabled to use Hardware Capture Register 2 to capture encoder position of X axis (since the X axis is attached to AXIS0) on the rising edge of external input 26 (Primary External for Capture Register 2) for the ACR8000 and ACR8010 ,the rising edge of external input 14 (Primary External for Capture Register 2) for the ACR2000 and ACR1200, or the rising edge of external I/O-2 (Primary External for Capture Register 2) for the ACR1500. It then waits for the capture and then prints the result.

```
10 INTCAP X2
20 INH 777
30 PRINT P12292
```

INTCAP

Encoder capture (continued)

Usage example2: (for ACR1200, ACR1500, ACR8010 and ACR2000 version 1.18 and above only)

This example is invalid for the ACR8000 board.

This example uses the INTCAP command, defining a hardware capture register for the ACR1200/ACR1500/ACR2000/ACR8010 boards. Using the INTCAP command in this way, the user defines the Hardware Capture Register to be used. The user may select any one of the available capture registers. The Interrupt Sources follow along with the Capture Register Selected.

The user also selects which Hardware Capture Parameter (and associated Capture Flag) is to be used to store the capture data. The user may select any one of the eight available capture parameters.

Example2 assumes ENC2 as position feedback on AXIS 0 (X) as follows:

```
ATTACH AXIS0 ENC2 DAC0 ADC0
```

In the following program, the INTCAP mode is enabled to use *Hardware Capture Register 1* to capture encoder position of X axis on the rising edge of external input 25 (Primary External for Capture register 1) for the ACR8010, the rising edge of external input 13 (Primary External for Capture register 1) for the ACR2000 and ACR1200, or the rising edge of external I/O-1 (Primary External for Capture register 1) for the ACR1500. It then waits for the capture and prints the result from the data stored in the selected Capture Parameter.

```
10 INTCAP X2 CAP1 P12804
20 INH 841
30 PRINT P12804
```

INTCAP OFF (Version 1.18.06)

Intcap is turned off

Format: **INTCAP OFF {AXIS}**
Group: Feedback Control

If the intcap mode is enable and the user wants to turn it off before the trigger happens then this command can be used to trun off the intcap.

Usage example1:

```
INTCAP X OFF
```

IPB

Set in-position band

Format: IPB { axis { value } } { axis { (value1, value2) } } ...
Group: Axis Limits
Units: units

See also: EXC, PPU

This command sets the following error limits monitored by the "not in-position" flags. When the following error of a given axis is outside of its in-position band, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if any of its slaves are outside of their in-position bands.

Issuing the IPB command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "value1" and the negative limit to "value2". The default for both is 0.0 for all axes.

The following is a table of 'not in-position' flags:

MASTER	BIT
0	528
1	560
2	592
3	624
4	656
5	688
6	720
7	752

AXIS	BIT
0	768
1	800
2	832
3	864
4	896
5	928
6	960
7	992

Table 3.11 'Not in-position' flags

Usage example:

This example sets an in-position band of ±0.5 units for X,Y and Z axes.

```
IPB X0.5 Y0.5 Z0.5
```

ITB

Set in-torque band

Format: ITB { axis { value } } { axis { (value1, value2) } } ...
Group: Axis Limits
Units: volts

See also: TLM

This command sets the voltage limits monitored by the "not in-torque band" flags. When the output voltage of a given axis is outside of its in-torque band, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if any of its slaves are outside of their in-torque bands.

The ITB only defines flag monitoring boundaries, it does not affect the analog output in any way. See the TLM command for information on physical output clipping.

Issuing the ITB command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "value1" and the negative limit to "value2". The default for both is 0.0 for all axes.

The following is a table of 'not in-torque band' flags:

MASTER	BIT
0	533
1	565
2	597
3	629
4	661
5	693
6	725
7	757

AXIS	BIT
0	773
1	805
2	837
3	869
4	901
5	933
6	965
7	997

Table 3.12 'Not in-torque band' flags

Usage example:

This example sets the torque band to 0.3 volts for X and Y.

```
ITB X0.3 Y0.3
```

IVEL

Set initial velocity

Format: IVEL { rate }
Group: Velocity Profile
Units: units / second

See also: VEL, ACC, DEC, STP, FVEL

This command sets the initial velocity value for a master move profile. If this value is zero (default) it is ignored. Otherwise, the move will start at this velocity regardless of the current ACC and DEC settings.

Issuing an IVEL command without an argument will display the current setting. The default initial velocity is zero. An error will be returned if no master is attached.

The following example sets the initial velocity to 1000 units / second:

Usage example:

```
IVEL 1000
```

JLM

Set jog limits

Format: JLM { axis { limit } } { axis { (plus, minus) } } ...
Group: Axis Limits
Units: units

See also: ALM, BLM

This command sets the jog limits for an axis. The jog limits are only checked when the "jog limit check" bit is set and the JOG FWD or JOG REV commands are in operation. The JOG ABS and JOG INC commands ignore jog limits even if the "jog limit check" bit is set. Jog limits only place limits on jog offset calculations. The primary and secondary setpoints are not part of the jog limits.

When the "jog limit check" bit is set, the JOG FWD command will jog to the positive jog limit and stop. If the current jog offset is greater than the positive jog limit, the JOG FWD command will do nothing. Likewise, the JOG REV command will jog to the negative jog limit and if the offset is less than the negative jog limit, JOG REV will do nothing.

Issuing the JLM command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "value1" and the negative limit to "value2". The default for both is 0.0 for all axes.

Usage example:

This example sets the X axis jog limits to +3.5 and -1.0 units:

```
JLM X(3.5,-1.0)
```

JOG

Single axis velocity profile

Format: JOG command { axis { data } } { axis { data } } ...
Group: Setpoint Control

See also: BKL, BSC, GEAR, HDW, CAM

This command is used along with a second command to initialize and control single axis velocity profiling, or "jogging". Jogging sets up an individual velocity profile for an axis based on the current jog parameters. This profile ramps to a given velocity, generating a jog offset. The jog offset is used during the summation of the primary setpoint.

The following is a list of valid jog command combinations:

`JOG VEL`	Set jog target velocity
`JOG ACC`	Set jog acceleration
`JOG DEC`	Set jog deceleration
`JOG SRC`	Set external timebase
`JOG RES`	Move jog offset into current
`JOG REN`	Move current into jog offset
`JOG FWD`	Jog axis forward
`JOG REV`	Jog axis backward
`JOG OFF`	Stop jogging axis
`JOG ABS`	Jog to absolute position
`JOG INC`	Jog incremental distance

Note:

The primary setpoint is the summation of the current position and the total cam, gear, and jog offsets. The secondary setpoint is the summation of the primary setpoint and the total ballscrew and backlash offsets. The secondary setpoint is the one that is actually used by the servo loop.

JOG

Single axis velocity profile (continued)

Related System Flags:

The following axis flags control and monitor jogging:

Jog Active	r	Set when jog is active. Must inhibit on this bit after a jog off to check for completion of decel ramp.
Jog Direction	r	Indicates the current jog direction. The bit is set when jogging in the negative direction.
Jog At Speed	r	Set when jog is active and the current jog velocity is equal to the target jog velocity.
Jog Stopping	r	Set when jog is active and jog forward and reverse bits are equal. Forces target velocity to zero.
Jog Forward	r/w	Set by FWD command. Can also be set manually to jog forward from within PLC or user program.
Jog Reverse	r/w	Set by REV command. Can also be set manually to jog backward from within PLC or user program.
Jog Limit Check	r/w	Activates the jog limits set with JLM command. See the description of JLM for more information.
Jog Lockout	r/w	Ignores jog forward and reverse flags if they would start a jog. Does not cancel a jog in progress.

r = read, w = write

Jog Flags	AXIS Number							
	0	1	2	3	4	5	6	7
Jog Active	792	824	856	888	920	952	984	1016
Jog Direction	793	825	857	889	921	953	985	1017
Jog At Speed	794	826	858	890	922	954	986	1018
Jog Stopping	795	827	859	891	923	955	987	1019
Jog Forward	796	828	860	892	924	956	988	1020
Jog Reverse	797	829	861	893	925	957	989	1021
Jog Limit Check	798	830	862	894	926	958	990	1022
Jog Lockout	799	831	863	895	927	959	991	1023

JOG VEL

Set jog velocity

Format: JOG VEL { axis { veloc } } { axis { veloc } } ...
Group: Setpoint Control
Units: units / second

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command sets the programmed jog velocity for an axis. Issuing a JOG VEL command to an axis without an argument will display the current setting for that axis. The default jog velocity is 0.0 for all axes, therefore this command must be issued before any jogging can occur.

The following example sets the X axis jog velocity to 10000 units / second:

Usage example:

```
JOG VEL X10000
```

JOG JRK

Set jog jerk (scurve)

Format: JOG JRK { axis { jerk } } { axis { jerk } } ...
Group: Setpoint Control
Units: units / second ^{3}

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command controls the slope of the acceleration versus time profile. If jerk is zero, the acceleration profile is rectangular. Otherwise, the acceleration profile is trapezoidal, clipped on top or bottom by the current JOG ACC and JOG DEC settings.

Issuing a JOG JRK command to an axis without an argument will display the current setting for that axis. The default jog jerk is 0.0 for all axes.

The following example sets the X axis jog deceleration to 80000 units / second ^{3}:

Usage example:

```
JOG JRK X80000
```

JOG ACC

Set jog acceleration

Format: JOG ACC { axis { accel } } { axis { accel } } ...
Group: Setpoint Control
Units: units / second ^{2}

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command sets the programmed jog acceleration for an axis. The jog acceleration is the ramp used when the current jog velocity is lower than the programmed value.

Issuing a JOG ACC command to an axis without an argument will display the current setting for that axis. The default jog acceleration is 0.0 for all axes.

The following example sets the X axis jog acceleration to 20000 units / second ^{2}:

Usage example:

```
JOG ACC X20000
```

JOG DEC

Set jog deceleration

Format: JOG VEL { axis { decel } } { axis { decel } } ...
Group: Setpoint Control
Units: units / second ^{2}

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command sets the programmed jog deceleration for an axis. The jog deceleration is the ramp used when the current jog velocity is higher than the programmed value. It is also used when the JOG OFF command is issued.

Issuing a JOG DEC command to an axis without an argument will display the current setting for that axis. The default jog deceleration is 0.0 for all axes.

The following example sets the X axis jog deceleration to 20000 units / second ^{2}:

Usage example:

```
JOG DEC X20000
```

JOG RES

Transfer jog offset into current position

Format: JOG RES { axis { offset } } { axis { offset } } ...
Group: Setpoint Control
Units: units

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command either clears or preloads the jog offset of a given axis and adds the difference to the current position. The default "offset" argument is zero. The current position and jog offset are adjusted according to the following formulas:

current_position = current_position + jog_offset - offset
jog_offset = offset

The following example transfers the X axis jog offset into the current position:

Usage example:

```
JOG RES X
```

JOG REN

Transfer current position into jog offset

Format: JOG REN { axis { offset } } { axis { offset } } ...
Group: Setpoint Control
Units: units

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command either clears or preloads the current position of a given axis and adds the difference to the jog offset parameter. The default "offset" argument is zero. The current position and jog offset are adjusted according to the following formulas:

jog_offset = jog_offset + current_position - offset
current_position = offset

If the optional "offset" parameter is left out, it is ignored. Otherwise, before the jog mode begins, the jog offset is reset as described in the JOG RES command.

The following example transfers the X axis current position into the jog offset:

Usage example:

```
JOG REN X
```

JOG FWD

Jog axis forward

Format: JOG FWD { axis } { axis } ...
Group: Setpoint Control

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command initiates a ramp to the velocity programmed with the set by the JOG VEL command. The "jog direction" bit is cleared and the "jog active" bit is set, causing the axis to target in on the positive jog velocity. When this velocity is reached, the "jog at speed" bit is set.

The following example starts the X and Y axis jogging in the positive direction:

Usage example:

```
JOG FWD X Y
```

JOG REV

Jog axis backward

Format: JOG REV { axis } { axis } ...
Group: Setpoint Control

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command initiates a ramp to the velocity programmed with the JOG VEL command in the negative direction. Both the "jog direction" and "jog active" bits are set, causing the axis to target in on the negative jog velocity. When this velocity is reached, the "jog at speed" bit is set.

The following example starts the Z axis jogging in the negative direction:

Usage example:

```
JOG REV Z
```

JOG OFF

Stop jogging axis

Format: JOG OFF { axis } { axis } ...
Group: Setpoint Control

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command initiates a ramp down to zero. The "jog stopping" bit is set, causing the axis to target in on a jog velocity of zero. When this target is reached, the "jog active" bit is cleared out.

The following example stops jogging of the X, Y and Z axes:

Usage example:

```
JOG OFF X Y Z
```

JOG SRC

Set external timebase

Format: JOG SRC axis sourcedef { axis sourcedef } ...
Group: Setpoint Control
Units: none

See also: SRC

This command specifies the timebase for jogging. See the SRC command for the definition of the "sourcedef" argument.

During each servo interrupt, the change in source pulses is multiplied by the servo period and the resulting delta time is fed into the jog mechanism. By default, jog is sourced off the CLOCK, feeding a single time unit per interrupt. Redirecting the jog source allows an external timebase to be used.

The following example sets the X axis jog source to encoder 3:

Usage example:

```
JOG SRC X ENC3
```

JOG INC

Jog an incremental distance

Format: JOG INC { axis offset } { axis offset } ...
Group: Setpoint Control
Units: units

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command will use the current jog settings to jog an axis an incremental distance from the current jog offset as indicated by the "offset" argument. This motion is independent from the attached master and can run on top of the current motion profile.

The JOG REN command may be used before JOG INC to transfer the current position into the jog offset. The JOG RES command may be used after JOG INC to transfer the jog offset back into the current position.

The following example jogs the Z axis 0.10 units from its current jog offset:

Usage example:

```
JOG INC Z0.10
```

JOG ABS

Jog to absolute position

Format: JOG ABS { axis target } { axis target } ...
Group: Setpoint Control
Units: units

See also: JOG, BKL, BSC, GEAR, HDW, CAM

This command will use the current jog settings to jog an axis to an absolute jog offset as indicated by the "target" argument. This motion is independent from the attached master and can run on top of the current motion profile.

The JOG REN command may be used before JOG ABS to transfer the current position into the jog offset. The JOG RES command may be used after JOG ABS to transfer the jog offset back into the current position.

The following example jogs the X and Y jog offsets to (1.25, 2.50) units:

Usage example:

```
JOG ABS X1.25 Y2.50
```

JRK

Set jerk parameter (scurve)

Format: JRK { rate }
Group: Velocity Profile
Units: units / second ^{3}

See also: ACC, DEC, STP, VEL, IVEL, FVEL, PPU

This command controls the slope of the acceleration versus time profile. If jerk is zero, the acceleration profile is rectangular. Otherwise, the acceleration profile is trapezoidal, clipped on top or bottom by the current ACC, DEC, and STP settings.

The following figure illustrates the result of using jerk on a normal move:

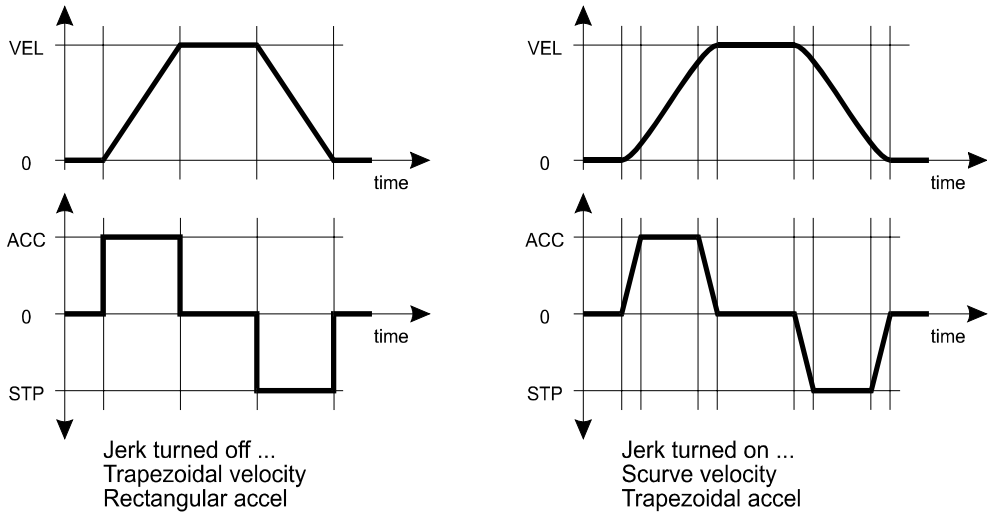


Figure 3.9 Scurve velocity profile

Issuing a JRK command without an argument will display the current setting. The default jerk is zero. An error will be returned if no master is attached.

The following example sets the jerk ramp to 80000 units / second ^{3}:

Usage example:

```
JRK 80000
```

KVF (Version 1.18.06 Update 05)

Feed forward gain for position velocity loop

Format: KVF { axis { value } } { axis { value } } ...
Group: Servo Control
Units: None

See also: KVI, KVP

This command modifies the feed forward gain of position–velocity loop. The default value is zero, which should be typically set to a non-zero value before turning the PV (position-velocity) loop ON by KVP. Issuing a KVF command to an axis without an argument will display the current setting for that axis.

The following example sets the X axis KVF to a value of 1.1.

Usage example:

```
KVF X 1.1
```

KVI (Version 1.18.06 Update 05)

Velocity integral gain for position velocity loop

Format: KVI { axis { value } } { axis { value } } ...
Group: Servo Control
Units: None

See also: KVF, KVP

This command modifies the Integral gain used in the position-velocity loop. Issuing a KVI command to an axis without an argument will display the current setting for that axis. The default value is 0.

The following example sets the X axis KVI gain to 100.

Usage example:

```
KVI X 100
```

KVP (Version 1.18.06 Update 05)

Position gain for position velocity loop

Format: KVP { axis { value } } { axis { value } } ...
Group: Servo Control
Units: None

See also: KVF, KVI

This command modifies the position gain in the position-velocity loop. Issuing a KVP command to an axis without an argument will display the current setting for that axis. The default value is 0, which implies that the PV loop is bypassed. Setting it to a non-zero value with turn on the PV loop.

The following example sets the X axis KVP gain to 1.

Usage example:

```
KVP X 1
```

LIMIT

Frequency Limiter

Format: LIMIT index command { data }
Group: Global Objects

See also: SRC, JOG, GEAR, CAM, RATCH

This command is used along with a second command to setup frequency limiters. The limiter "index" is a number from 0 to 7. Frequency limiters are sources that can limit the frequency of incoming pulses and redistribute large impulses over time.

Incoming pulses are multiplied by the limiter “multiplier” and accumulated over the limiter frame “width”. At the end of each frame, the accumulated pulses are compared to the limiter “frequency” times the limiter “width” and any excess pulses are thrown away. The remaining pulses are redistributed evenly during the following frame.

The following is a list of valid limiter command combinations:

`LIMIT SRC`	Define limiter source
`LIMIT FREQ`	Set frequency limit
`LIMIT WIDTH`	Set pulse redistribution width
`LIMIT MULT`	Set incoming pulse multiplier

LIMIT SRC

Define limit source

Format: LIMIT index SRC sourcedef
Group: Global Objects
Units: none

See also: SRC

This command sets the input source for a limiter. The default limiter source is NONE. See the SRC command for the definition of the "sourcedef" argument.

The following example sets the source of LIMIT0 to RATCH2:

Usage example:

```
LIMIT0 SRC RATCH2
```

LIMIT FREQ

Define frequency limit

Format: LIMIT index FREQ frequency
Group: Global Objects
Units: pulses / second

This command sets the limiter “frequency”. The limiter “frequency” sets the maximum frequency allowed to pass through the limiter. The limiter “frequency” times the limiter “width” determine the maximum pulses per frame.

Setting limiter “frequency” to zero tuns off the limiter’s frame clipping and all pulses accumulated in the previous frame are redistributed over the next frame.

The “frequency” argument is a 32-bit floating point. Issuing a LIMIT FREQ command without an argument will display the current setting. The default frequency limit is zero.

The following example sets the frequency limit of LIMIT1 to 10000 pulses / second:

Usage example:

```
LIMIT1 FREQ 10000
```

LIMIT WIDTH

Set pulse redistribution width

Format: LIMIT index WIDTH width
Group: Global Objects
Units: seconds

This command sets the limiter “width”. The limiter “width” sets the width of the limiter frame. The limiter “frequency” times the limiter “width” determine the maximum pulses per frame. Pulses from one frame are redistributed over the next frame.

Setting limiter “width” to zero causes the limiter to send multiplied pulses directly down the source chain without frame buffering. Setting the limiter “width” to too large of a value will cause unacceptable sluggishness in the limiter’s response.

The “width” argument is a 32-bit floating point. Issuing a LIMIT WIDTH command without an argument will display the current setting. The default redistribution width is zero.

The following example sets the pulse redistribution width of LIMIT3 to 50 milliseconds:

Usage example:

```
LIMIT2 WIDTH 0.050
```

LIMIT MULT

Set incoming pulse multiplier

Format: LIMIT index MULT multiplier
Group: Global Objects
Units: none

This command sets the limiter “multiplier”. Incoming pulses are scaled by the “multiplier” before being accumulated into the frame buffer.

The “multiplier” argument is a 32-bit long integer. Issuing a LIMIT MULT command without an argument will display the current setting. The default pulse multiplier is one.

The following example sets the pulse multiplier of LIMIT3 to 100 times:

Usage example:

```
LIMIT3 MULT 100
```

LIST

List a stored program

Format: LIST { first } { , { last } }
Group: Program Control

This command lists the currently selected program. The LIST command cannot be issued from within a program or while at the system level.

The operands "first" and "last" define the listing range as follows:

LIST first	Lists a single line
LIST first, last	Lists from "first" to "last"
LIST first,	Lists from "first" to end of program
LIST ,last	Lists form start of program to "last"

Usage example:

```
LIST 100,199
```

LISTEN

Listen to program output

Program Control

Format: LISTEN
Group: Program Control

See also: LRUN

This command will link the current communication channel into a program's output. The LISTEN command cannot be issued from inside a program.

Normally, when a program is run, the communication channel returns to the command prompt, allowing more commands to be entered. While at the command prompt, output from programs (including error reporting) is shut down to prevent mixing of command input and program output.

Issuing an LISTEN command suspends the command prompt until an escape character (ASCII 27) is received or the program ends, allowing program output to be monitored. The LRUN command will run a program and leave the channel in the "listen" state.

Usage example:

```
LISTEN
```

LOCK

Lock gantry axis

Format: LOCK { axis1 axis2 } { axis1 axis2 } ...
Group: Setpoint Control
Units: none

See also: UNLOCK, BSC, CAM, GEAR, HDW, JOG

This command redirects "axis1" to follow the primary setpoint of "axis2". The actual position parameter of the axis is adjusted such that there is no change in following error when the primary setpoint switches. The UNLOCK command can be used to release the redirection. The default state of an axis is to follow its own setpoint.

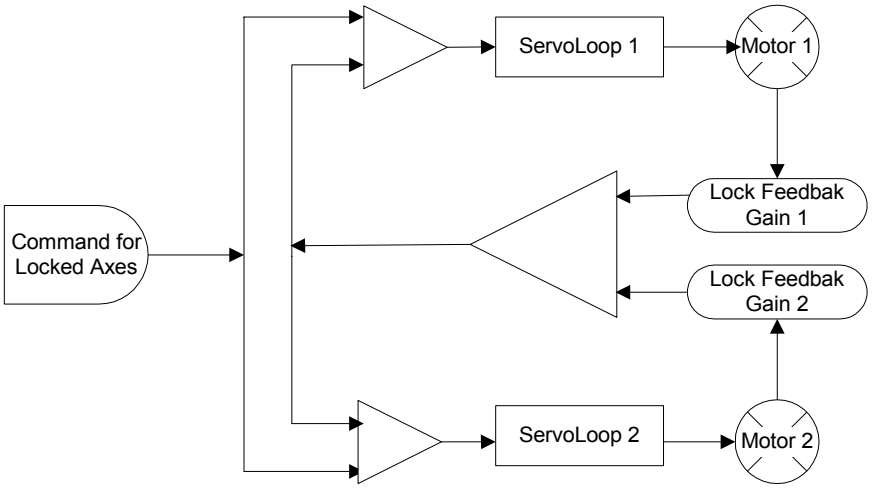
Each axis generates a primary setpoint based on its current position, gear offset, jog offset, and cam offset. This number is normally used to tell the axis where it should be at any given time. The LOCK command tells an axis to use the primary setpoint of a different axis instead of its own. The UNLOCK command tells an axis to use its own primary setpoint once again..

The following example locks axis XB to the primary setpoint of axis XA :

Usage example:

```
LOCK XB XA
```

Lock Feed Back Gain **(Version 1.18.04)**



LOCK

Lock gantry axis

When two axes are locked together by using the LOCK command, then their primary set points becomes the same, in other word the two axes will get exactly the same command signal. However in real world, the response of the two physical motors/actuators will be slightly different. To compensate for this error the user can turn on a feedback loop by setting some gain values for " Lock Feed Back Gain" parameter of the locked axes. The default value is zero, which forces this feedback loop to be off.

Usage example:

```
P12376 = 3.5
P12632 = 3.5

LOCK Y X
X /20
UNLOCK Y
```

Look Ahead

This special feature is used for velocity profiling. It acts as an intelligent observer and monitors and controls the velocity depending on the motion path shape and distance to travel.
This mode can be used, with and without, the multi-buffer mode (MBUF ON). However it will be more effective with multi-buffer mode as there will be more moves buffered to lookahead, especially in case of tiny moves.

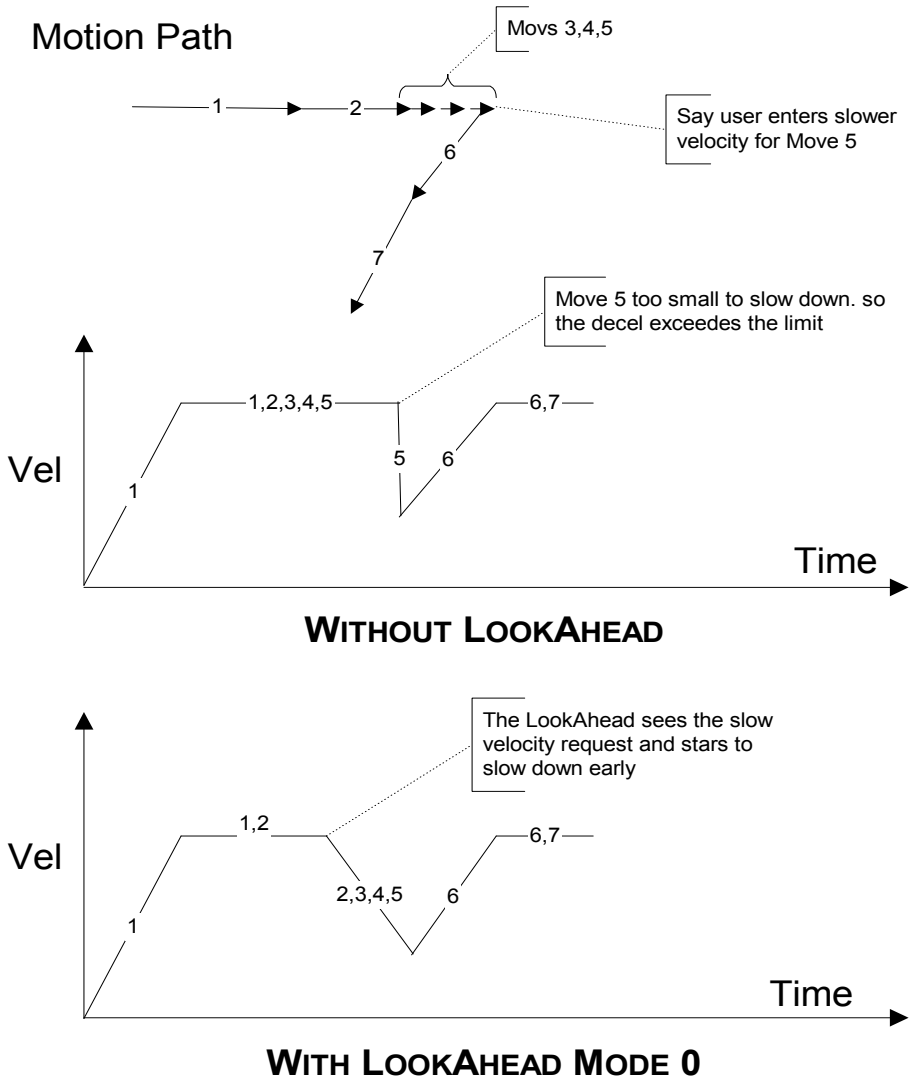


Figure 3.9a Look Ahead Mode 0

LOOK ON (Version 1.18.06 Update 09)

Look ahead mode is turned on

Format: **LOOK ON**
Group: Velocity Profile

The LOOK ON command is used to turn on the Lookahead feature for a particular master. Once this mode is truned on it will stay on unless the user explicitly turns it off. Issuing this command without an argument will display the current setting of this mode.

Usage example:

```
P00> LOOK ON
P00>LOOK
LOOK ON
LOOK ANG  (0, 180)
LOOK MODE 0
```

LOOK OFF (Version 1.18.06 Update 09)

Look ahead mode is turned off

Format: **LOOK OFF**
Group: Velocity Profile

The LOOK OFF command is used to turn off the lookahead mode for a master.

Usage example:

```
LOOK OFF
```

LOOK MODE (Version 1.18.06 Update 09)

Set look ahead mode

Format: **LOOK Mode {number}**
Group: Velocity Profile

The default mode is 0. The mode 0 will work with any number of dimensions whereas mode 1 is only valid up to 3-dimensions.

- **Mode 0** It tries to follow the user set velocities. It can see that the user has programmed a slower velocity at the end of so many moves and start to slow down in advance when there is not enough distance left.
- **Mode 1** In addition to the above feature, this mode also looks at the geometry of the motion path. By doing so it gets the ability to foresee *sharp corners* and *small radius arcs* and automatically reduce speed according to the user set specifications.

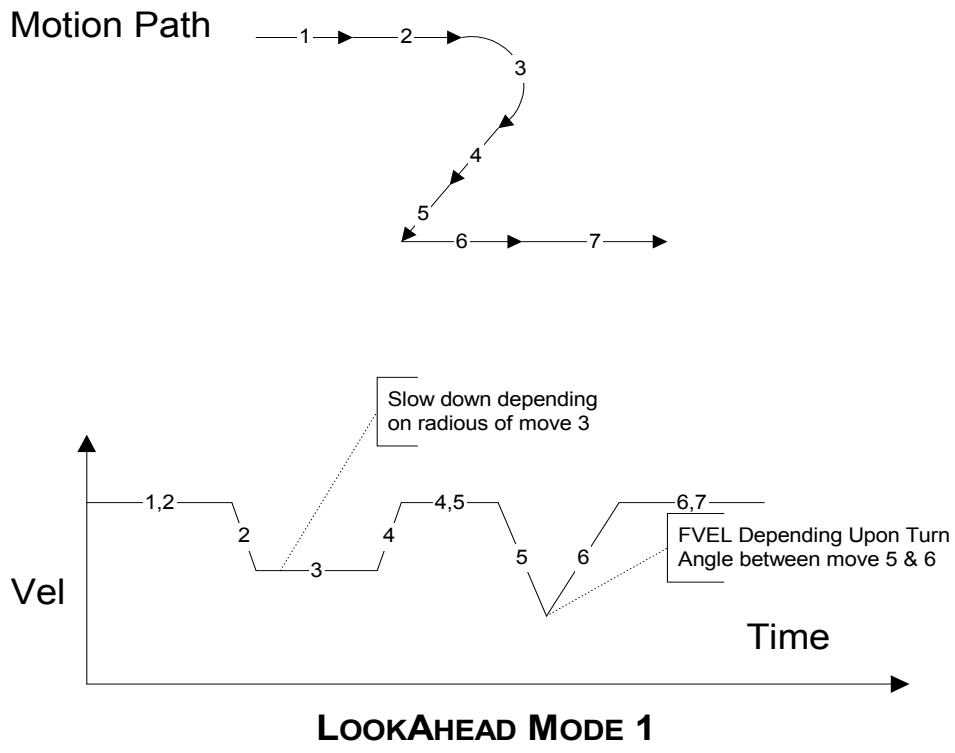


Figure 3.9b Look Ahead Mode 1

Usage example:

```
LOOK MODE 1
```

LOOK ANG (Version 1.18.06 Update 09)

Set the angles for corner sharpness

Format: **LOOK ANG {min angle, max angle}**

Group: Velocity Profile

Unit: Degrees

The Look ahead mode 1 uses the min angle θ1, max angle θ2 and sharpness of the corner to determine the velocity. The default value for θ1 and θ2 are 0 and 180-degree respectively.

For Linear moves, the relationship between the angles and velocity profiler is

Vector Turn Angle < θ1	No change in velocity
Vector Turn Angle >θ2	The velocity at the corner goes down to master parameter " LookAhead Minimum Velocity"
θ1 <Vector Turn Angle < θ2	The velocity goes proportionally from max to min as the turn angle goes from θ1 to θ2.

$$V_f = V * \left(\frac{\theta_2 - \psi}{\theta_2 - \theta_1} \right)$$

Where

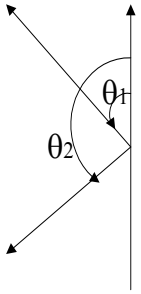
V_f = Final velocity or sharp corner speed

V = VEL = User Programmed Velocity

θ_1 = Minimum Look Angle

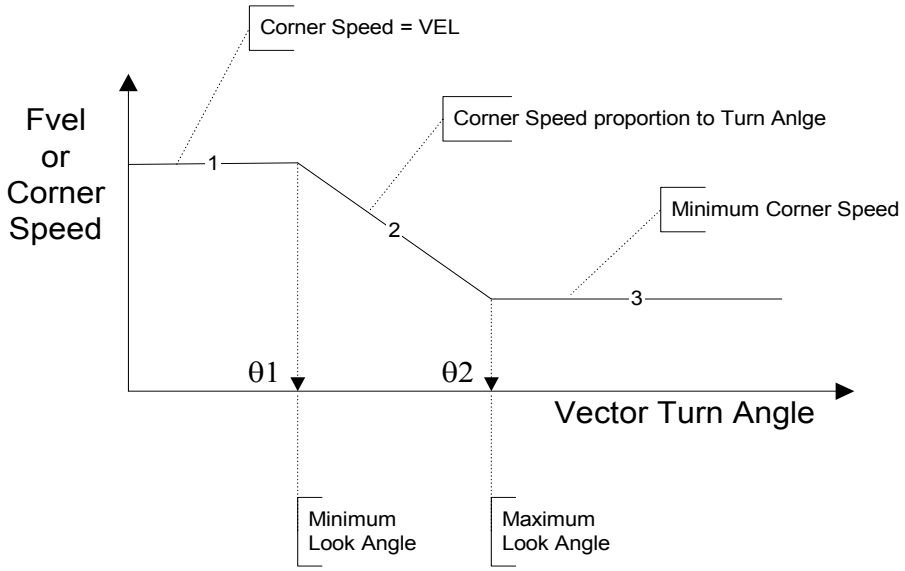
θ_2 = Maximum Look Angle

ψ = Vector Turn Angle



Continued

Corner Speed As A Function Of Turn Angle



In case of a circular or arc moves the above is not used. Instead centripetal acceleration is used to calculate the master velocity as follows

$$v = \sqrt{a.R}$$

where

$v = Velocity$

$a = Acceleration$

$R = Radius$

Usage example:

```
LOOK ANG (10, 90)
```

LOPASS

Setup lopass filter

Format: LOPASS { axis cutoff } { axis cutoff } ...
Group: Servo Control
Units: Hertz

See also: NOTCH, PGAIN, IGAIN, DGAIN, FFVEL, FFACC

This command initializes the second half of the output filter to act as a lopass filter, reducing high-frequency noise that may occur in a system. Setting the cutoff frequency to zero turns off the lopass filter.

The following example sets the X axis lopass filter to a cutoff frequency of 500 hertz.

Usage example:

```
LOPASS X500
```

LRUN

Run and listen to a program

Format: LRUN { line }
Group: Program Control

See also: RUN, HALT, LISTEN

This command will run the current program and leave the communication channel linked to the program's output. The LRUN command cannot be issued from inside a program. Issuing an LRUN command with the optional "line" argument will start program execution at the given line number.

Normally, when a program is run, the communication channel returns to the command prompt, allowing more commands to be entered. While at the command prompt, output from programs (including error reporting) is shut down to prevent mixing of command input and program output.

Issuing an LRUN command runs a program but does not return to the command prompt until an escape character (ASCII 27) is received or the program ends, allowing program output to be monitored. The LISTEN command forces the communication channel back into this state from the command prompt.

Usage example:

```
LRUN
```

MASK (Version 1.16.06 & Up)

Safe bit masking

Format: MASK parameter (nandmask, ormask)
Group: Logic Function

See also: CLR, INH, BIT

This command sets and clears multiple bits in a parameter and prevents the parameter from being corrupted by another program doing the same thing. The “nandmask” is used to clear bits and the “ormask” is used to set bits. The command replaces the following typical parametric expression:

parameter = (parameter AND NOT nandmask) OR ormask

The following example clears out the lower 8 bits of P4097 using 255 (FF hex) and replaces them with 85 (55 hex)

Usage example:

```
MASK P4097(255,85)
```

MASTER

Direct master access

Format: MASTER index command { data }
Group: Global Objects

See also: ENC, DAC, AXIS

This command allows direct access to a master without having to be at the required program level. The master does not have to be attached to a program. The "command" argument can be any command from the velocity profile group.

The following example sets the MASTER 2 velocity to 1000 and MASTER 4 feedrate override to 75 percent :

Usage example:

```
MASTER2 VEL 1000
MASTER4 FOV 0.75
```

MAXVEL (Version 1.18.04 & Up)

Axis Velocity Limit

Format: **MAXVEL {axis} {value}**
Group: Axis Limits
Units: Units/second

See also: TMOV

This command sets the velocity limit for individual axis. This is useful for optimizing the speed of the machine with axes that can handle different velocity limits. Depending on the axes involved in the move and the size of their moves, the profiler will automatically adjust to make a maximum velocity move, overriding the VEL value for the move. This mode can be used with the TMOV command, as well.

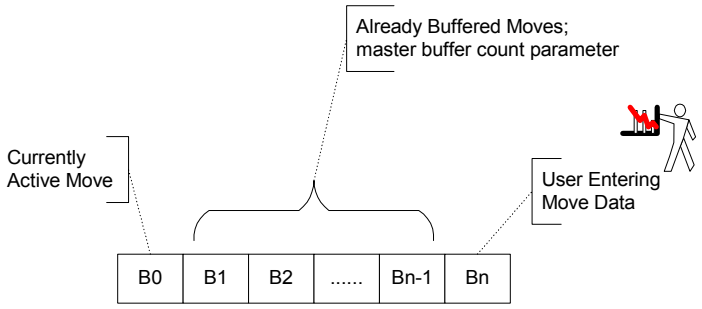
The maxvel is store in axis paramter " MaxVel " and its default value is zero. When all the axes attached to a master have the MAXVEL value set to greater then zero, this mode is automatically turned on. This is indicated by master secondary flag 'SlaveMaxVel'. This mode will turn off, if one or more of the attached axes MAXVEL velocities are set to zero or by clearing the master secondary flag 'Slave MaxVel'.

Usage example:

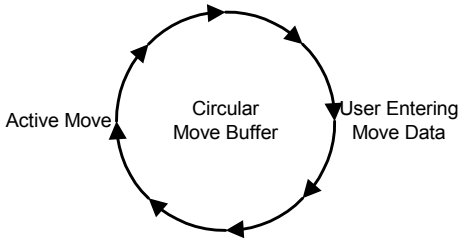
```
MAXVEL X 5
MAXVEL Y 2
```

Multiple move buffer

This command is used along with a second command to define the length of the move buffer. The default value for the move buffer is 2 i.e., one active move and one buffered move. This default move buffer is in the system memory. In some applications the user may want to increase the number of moves buffered. This can be done by using DIM MBUF command from PROG level prompt to allocate program level user memory for the move buffer.



MBUF MAX = Bn



MBUF ON (Version 1.18.06 Update 09)

Multiple moves buffered for motion profiler

Format: **MBUF ON**
Group: Velocity Profile

The MBUF ON command is used to set the master in multi-buffer mode. Issuing just MBUF command will display the current length of the buffer and its status, whether it is on or off.
By using this mode one can increase the throughput (moves per second), since the tiny moves can get buffered in advance and consequently cut the processing time. Besides this one can use features like LookAhead more effectively.

Usage example:

```
CLEAR
DIM MBUF (20)
MBUF ON
:
:
MBUF OFF
```

Note

DIM MBUF command should be issued each tie the MBUF is turned on.

MBUF OFF (Version 1.18.06 Update 09)

Single move will be buffered for the motion profiler

Format: **MBUF OFF**
Group: Velocity Profile

The MBUF OFF command is used to turn off the master multi-buffer mode. This command will wait for master in motion flag to clear and then it will clear all the buffers. By turning the mode off, the controller will go back to its default state, that is, one active move and one buffered move.

Usage example:

```
MBUF OFF
```

MEM

Display memory allocation

Format: MEM
Group: Memory Control

See also: DIM, CLEAR

This command displays the amount of memory remaining, in bytes. From the system level, the command displays the amount of memory that can be allocated to a program. From the program level, the command displays the amount of memory available for program, variable, and array storage.

The MEM command cannot be issued from within a program.

Usage example:

```
MEM
```

MODE

Binary Data Formatting

Format: MODE { mode }
Group: Operating System

This command controls the encoding and decoding of the data fields in immediate mode commands (see Binary Host Interface.) Issuing a MODE command without an argument displays the current setting. The default setting for the FIFO channel is 0 and the default for the COM1 and COM2 channels is 1.

Control character prefixing and high bit stripping follow Kermit communications protocol conventions. The escape code for control prefixing is the '#' character and the escape code for high bit stripping is the '&' character.

These sequences were added primarily for the serial communication channels. The control prefixing was added to prevent valid data within a binary packet from being confused with the XON / XOFF flow control codes. The high bit stripping was added for cases in which a 7-bit data path must be used. In general, the FIFO channel does not require these precautions.

The following table lists the valid data formatting modes. Note that it is not possible to activate high bit stripping without also activating the control character prefixing.

Mode Value	High Bit Stripping	Control Prefixing
0	OFF	OFF
1	OFF	ON
2	OFF	OFF
3	ON	ON

Table 3.13 Data formatting modes

The following example turns on both control prefixing and high bit stripping:

Usage example:

```
MODE 3
```

MOV

Define a linear move

Format: MOV { axis target } { axis target } ...
Group: Interpolation
Units: units

See also: TRJ, SINE, PPU, TMOV, SPLINE, NURB, MAXVEL

This command activates the linear interpolation mode. Since this is the default axis data input mode, the command is usually redundant.

When a forward slash (/) is used, the move is interpreted as an incremental move of the number of units specified, rather then an absolute move to a position.

Usage examples:

`MOV X10`	Moves x-axis to absolute position of 10 units.
`X10`	MOV command is redundant. This command will also move the x-axis to absolute position of 10 units.
`X20 Y-30`	Coordinated move, since both axes are on the same command. The X and Y axes start and finish their respective moves exactly at the same time.
`X/20`	X-axis moves an incremental distance of 20 units from it's current position.
`Y/-30`	Y-axis moves a decremental distance of 30 units from it's current position.
`X/2 Y2 Z/-2`	X-axis makes an incremental move, Y-axis makes an absolute move, and Z-axis makes a decremental move. This is a coordinated move, so all axes finish their respective moves exactly at the same time.
`X2 SINE Y(0,90,90,100)`	A coordinated move with the X-axis doing linear-interpolation and the Y-axis doing sinudoidal interpolation.

MSEEK

Marker seek operation

Format: MSEEK { axis (incmove, mode) {capture_register} } {axis (incmove, mode) {capture_register}} ...
Group: Feedback Control

See also: INTCAP

This command initiates a marker seek operation. A master can only control one MSEEK at a time. If multiple axes are indicated, they will execute in the order that they appear.

NOTE: Refer to the mode parameter and hardware capture register information in the INTCAP command section. The mode parameter and hardware capture register for the MSEEK is the same as those used in the INTCAP command.

A marker seek operation is as follows:

1. Start an incremental move. Start looking for marker.
2. When marker is located, decelerate to a stop.
3. Reverse direction and move back to where marker was located.
4. Reset encoder to zero and terminate MSEEK mode.

If the incremental move ends without the marker being located, the corresponding "capture complete" flag will not be set. Typically, the incremental move should be large enough to guarantee a complete revolution (at least 1.5 revolutions are suggested.)

NOTE: The incremental move is specified in units.

When an MSEEK command is performed, the FLZ offset register is cleared by the processor. It is recommended that the user also clears the CAM, Gear, and Jog registers by performing the following command sequence:

```
CAM OFF
CAM RES
GEAR RES
JOG OFF
JOG RES
```

The following example assumes ENC0 as position feedback on AXIS0 (X). The MSEEK command moves the X axis to its marker position.

Usage example1:

```
10 MSEEK X(10000,0)
```

Usage example2: **(version 1.18)**

```
10 MSEEK X(10000,9) CAP2
```

MULT

Set encoder multipliers

Format: MULT { axis { mode } } { axis { mode } } ...
Group: Feedback Control

This command sets up count direction and hardware multiplication for the encoder attached to the given axis. Issuing the MULT command to an axis with no argument will display the current setting. The default setting is 1 for all axes.

Valid modes:

0	0x multiplier, encoder turned off, no quadrature counts
1	1x multiplier, count up on rising edge of A channel
2	2x multiplier, count up on both edges of A channel
4	4x multiplier, count up on edge of either channel
-1	1x multiplier, count down on rising edge of A channel
-2	2x multiplier, count down on both edges of A channel
-4	4x multiplier, count down on edge of either channel

The following example sets hardware multiplication for axis X to 1 and axis Y to 2:

Usage example:

```
MULT X1 Y2
```

NEW

Clear out a stored program

Format: NEW { PROG number | PLC number | ALL }
Group: Program Control

This command erases the currently selected program. An error will be generated if the program to be erased is currently running. Data lost when programs are erased cannot be recovered. The NEW command cannot be issued from within a program.

The optional NEW formats can be issued from anywhere, including programs. The NEW PROG and NEW PLC commands will erase the corresponding user or PLC program. The NEW ALL command will erase all user and PLC programs that are not currently running.

Usage example:

```
NEW
```

NORM

Normalize current position

Format: NORM { axis { length } } { axis { length } } ...
Group: Feedback Control
Units: units

See also: ROTARY, RES, REN, PPU

This command normalizes the current position of an axis. A "MOD" operation is done on the current position, resulting in a new current position between zero and the "length" argument. The primary setpoint and the encoder count are adjusted accordingly in order to prevent the axis from jumping. If the "length" argument is left out, the rotary length set by the ROTARY command is used.

The following example normalizes the A axis to 360 units:

Usage example:

```
NORM A360
```

NOTCH

Setup notch filter

Format: NOTCH { axis (center, width) } { axis (center, width) } ...
Group: Servo Control
Units: Hertz

See also: LOPASS, PGAIN, IGAIN, DGAIN, FFVEL, FFACC

This command sets up the first half of the output filter to act as a notch filter, reducing mechanical resonance that may occur in a system. Setting the center frequency to zero turns off the notch filter.

The following example sets the X axis notch filter to a center frequency 100 hertz and bandwidth of 50 hertz.

Program Usage example:

```
NOTCH X(100,50)
```

NURB (Version 1.18.04 and Up)

Non-Uniform Rational B-Spline Interpolation

Format: NURB command
Group: Interpolation

See Also: SPLINE

This mode is not available on the ACR1500 or ACR8000 boards.

With NURB interpolation, the NURB curve points generated by a CAD/CAM package can be directly downloaded to the board. Thus, no need to generate and download huge amounts of data approximating the NURB curve with small linear moves. The CAD/CAM package creates the NURB data with tool compensation.

The following is a list of valid NURB command combinations:

`NURB MODE`	Enable NURB Interpolation Mode Type
`NURB RANK`	Set NURB Rank value
`NURB END`	End NURB Interpolation

The following is a typical single NURB command format for a 2-D curve with X and Y axes.

K 3	X5	Y / 2	W 2.3	VEL 5
Knot Value of 3	Absolute control point for x-axis	Incremental control point for y-axis	Weight of x-y control point	velocity from previous knot to this knot

The weight ‘W’ and velocity ‘VEL’ are optional in the above command, and if omitted, the previous value is used.

NURB

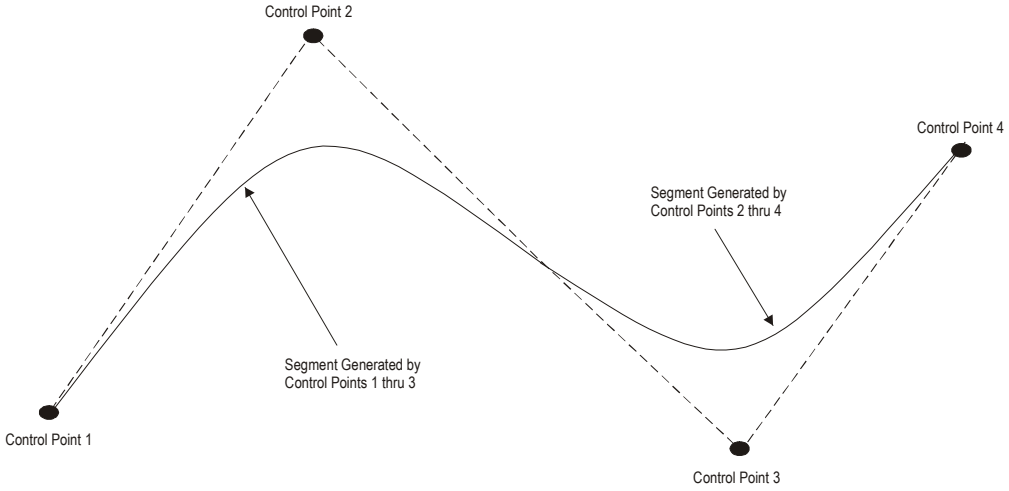
Non-Uniform Rational B-Spline Interpolation, continued

The NURB curve is defined using these variables:

R = Rank
N = Degree = R-1
P = Control point
W = Weight of each control point; number of W = number of P
K = knot; number of knots number of P + R
u = NURB parameter

Rank:

Rank is used to define how many control points are used to generate an individual segment within a NURBS curved line. The following illustration uses a NURB RANK value of Rank 3 (degree2). There are two segments that generate the NURBS curved line using four (4) control points.



Weight:

The default value is "1" and the keyword 'W' is used to define the weight of a control point. Increasing the weight of a control point will result in increasing the effect of control point on the NURB curve and vice versa.

Knot:

Keyword 'K' is used to define the knots of NURB curve.

Number of knots = Number of Control Points + NURB Rank

The first and last R knots (where R is the rank) must specified as duplicated values. In other words, the first R knots should be zero and the last R knots should have the same value.

The knots are a strictly non-decreasing function and giving a negative value to a knot (i.e. –1) will end the NURB move block.

NURB

Non-Uniform Rational B-Spline Interpolation, continued

Control Point:

The control points are given as the target points to the axes. These could be absolute or incremental values.

A NURB curve starts from the first control point and ends at the last control point. The first control point must be current position of axes or the target point of the previous move.

The following example uses the control points as indicated in the following figure to generate the resulting NURB curve as traced.

Note

In this mode, the board is using N+R+1 points to calculate NURB curve. If stopped by DWL or INH commands, the move will stop R+1 points before the command appeared.

At the point where the negative knot is read by NURB profiler, the profiler knows that the block is ending, so the user should keep the speed and distance in the last segment such that there is enough time to slow down.

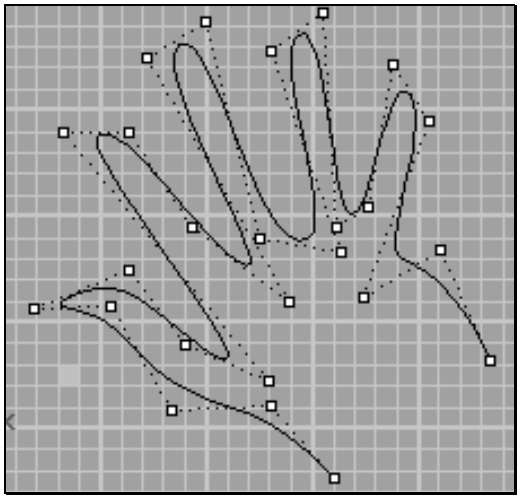


Figure 3.9c NURB interpolation example

NURB

Non-Uniform Rational B-Spline Interpolation, continued

Usage example:

```
PPU X 1000 PPU Y 1000
ACC 1 IVEL 0                    Initial velocity of zero is set
NURB RANK 4                     Rank of 4  (i.e. a degree of 3 is selected)
NURB MODE 1                     Dynamic Interpolation Mode is selected
                                This command should be given each time
                                before starting the NURB block.

K 0 X23 Y8  VEL 4
K 0 X21 Y13.4  VEL 5            Notice the first four multiple knots of zero
                                VEL 5 will be used from the 1st to 2nd
                                control point
K 0 X17.4 Y11.2  VEL 4          VEL 4 will be used from 2nd to 5th control
                                point.
K 0 X20.6 Y19.5
K 2.96  X18.8 Y22.1
K 5.83 X17.7 Y15.5 VEL 2
K 7.17 X16.1 Y14.5 VEL 4
K 9.82 X15.5 Y24.6  W2          A weight of 2 is used for this control point
K 10.82 X13.1 Y22.8
K 13.76  X16.4 Y13.4
K 14.98 X12.5 Y14
K 18.1 X10 Y24.2 W1.1 VEL       VEL command used to control the speed
5
K 19.58 X7.2 Y22.5
K 22.6 X13.9 Y11
K 24.04 X9.3 Y14.5
K 27.04 X6.3 Y19
K 28.34 X3.3 Y19
K 31.17 X12.9 Y7.2
K 32.58 X9.03 Y8.9
K 36.3 X6.4 Y12.6
K 37.79 X1.9 Y10.6
K 40.39 X5.5 Y10.8
K 41.92 X8.4 Y5.8
K 43.98 X13.1 Y6.1
K 46.21 X16.8 Y2.7 VEL          Finally slowing down.
0.2
K 49.4                          The last four multiple knots
K 49.4
K 49.4
K 49.4
K –1                            Negative knot indicates that NURB block
                                has ended.
```

NURB MODE (Version 1.18.04 and Up)

Enable NURB mode

Format: NURB MODE {value} ...

A NURB MODE command must be issued each time before a NURB block of moves. The subsequent move commands are treated as NURB control points, and NURB interpolation is used to trace the NURB curve. This modes remains active until a negative knot is received, Kill Move Flag is set, or the user issues a NURB END command.

NURB Interpolation Modes

To give control over machine speed following modes are available. The user decides which one to use, depending upon the application.

MODE	NURB TYPE	TOV	FOV	DESCRIPTION
0	Time Interpolation	Yes	NA	• The knots are taken as time. • Automatically adjusts velocity and acceleration depending on the knots. • The master parameter NURB Time Factor may be used to scale the knots to time and change the speed. • Very smooth and good for high speed precise moves.
1	Dynamic Interpolation	Yes	Yes	• User specifies the speed and acceleration limits. • Depending on the curvature of the curve and acceleration/velocity limit set be the user, automatically controls the speed. • User should watch for sharp turns and slow down in time to make a smooth turn.
2	Linear Interpolation	Yes	NS	• Linearly maps linear-arc-length/VEL time to knots. • The velocity command starts effective from the start of the segment.
3	NR Interpolation	Yes	Yes	• Newton Raphson Approximation for Vector Velocity Control
4	Smooth Interpolation	Yes	NS	• Uses Cubic Spline to map arc-length/VEL time to knots. • The smoother trajectory comes at the cost of slowing down close to each knot to make a smoother transition.

NA: Not Applicable
NS: FOV value is applied to the next segment

Usage example:

The following examples selects Time Interpolation Mode for all following NURB commands.

```
NURB MODE 0
```

NURB RANK (Version 1.18.04 and Up)

Set the order of NURB interpolation

Format: NURB RANK {value} ...

The default NURB rank is 4 (degree of 3). The valid values for NURB rank are 2,3,4,5. The user can change this value by issuing the NURB RANK command. This command should not be used while the NURB profiler is in motion

The following example set the NURB Rank to 3 (degree of 2).

Usage example:

```
NURB RANK 3
```

NURB END (Version 1.18.04 and Up)

Ends NURB Interpolation Mode

Format: NURB END

This command is used to terminate the NURB interpolation mode initiated by the NURB MODE command.

The NURB ending is automatically done, if the NURB motion has normally come to end/stop by a negative knot. However, if stopped abnormally, like issuing incomplete or wrong data to the NURB profiler, then this command must be used to terminate the NURB mode.

Usage example:

```
NURB END
```

OFFSET

Absolute program path shift

Format: OFFSET { axis { offset } } { axis { offset } } ...
Group: Transformation

See also: SCALE, ROTATE, FLZ

This command will cause the programmed path to be shifted. The amount of the path shift is defined by the "offset " data. If the offset_value for an axis is not specified, the zero location for that axis will be equal to its current location.

Usage example:

```
10 OFFSET X10000 Y20000
```

OPEN

Open a device

Format: OPEN "device string" AS #device
Group: Character I/O

See also: PRINT, INPUT, CLOSE

This command opens a device. The valid range for "device" is 0 to 3. Each program has it's own device #0 which is used as its default device. Devices #1 through #3 are board-wide system resources that can be opened and used from within any program or from any system or program prompt.

The "device string" describes the device that is to be opened. Serial device strings contain information required to set up communications. Valid device strings are:

```
"FIFO:"
"DPCB:"
"COM1:baudrate,parity,databits,stopbits"
"COM2:baudrate,parity,databits,stopbits"

baudrate = 300,600,1200,2400,9600,19200,38400
parity   = N,E,O
databits = 5,6,7,8
stopbits = 1,2
```

When a device is opened, the operating system attached to that device enters an idle state, allowing incoming characters to be used by a program instead of being interpreted as commands. When the device is closed, the device will enter its auto-detect mode as if it were starting from power-up.

Usage example:

```
10 OPEN "COM1:9600,N,8,1" AS #1
20 PRINT #1, "Hello world!"
30 CLOSE #1
```

PASSWORD (Version 1.18.06 Upd 9)

Password

The password feature is to lock certain commands so that once the password is on these commands can't be used.

PASSWORD ON (Version 1.18.06 Upd 9)

Password is turned on

Format: **PASSWORD ON {string}**
Group: Operating System

This command is issued with password string to turn the password on. The password can be any ascii string from 6 to 16 characters. It is only accepted by the board if the password is currently off. If the password is turned on from the SYS promt, then the user can not LIST or UPLOAD any programs or PLCs from the board. If the password is turned on from the PROGn promt, then the user can not LIST or UPLOAD that particular program. Once the password is turned on it will stay on even if the power is truned down. FLASH ERASE, CLEAR or ERASE comand will not clear the password. The user must use the password string with password off command to trun it off.

Usage example:

```
PROG0>PASSWORD ON "abcdef"
PROG0>LIST
Wrong Password
```

PASSWORD OFF (Version 1.18.06 Upd 9)

Password is turned off

Format: **PASSWORD OFF {string}**
Group: Operating System

This command with password string will turn off the password. The password will remain off till the user turns it on again.

Usage example:

```
PROG0>PASSWORD OFF "abcdef"
PROG0>LIST
10 SET 32
20 PRINT " bit set"
20 END
```

PAUSE

Activate pause mode

Format: PAUSE { PROG number | ALL }
Group: Program Control

See also: RUN, HALT, TRON, TROFF, AUT, BLK, STEP, RESUME

This command pauses the currently selected program by setting the program's "pause control" bit. If there is no master attached, the "pause mode" bit is set as soon as the "pause control" is detected. Otherwise, the program will feedhold and then set "pause mode" when the master "in feedhold" is detected.

Master cycle start requests and STEP commands are ignored while in pause mode.

The PAUSE PROG command will pause the corresponding program and the PAUSE ALL command will pause all programs. These commands can be issued from anywhere in the system, including programs.

The following example pauses the current program:

Usage example:

```
PAUSE
```

PBOOT

Auto-run program

Format: PBOOT
Group: Nonvolatile

See also: ELOAD, ESAVE, ERASE, BRESET

This command allows programs & PLC's to run automatically on power-up. When power is applied to the card, the operating system checks the beginning of all programs & PLC's for the PBOOT command and sets their run request flag if the command is present.

The power-up PBOOT check can also be initiated manually by issuing the PBOOT command from anywhere in the system. This allows the PBOOT sequencing to be tested without resetting or removing power to the card.

The following program will run on power-up, flashing output 32:

Usage example:

```
10 PBOOT
20 BIT 32 = NOT BIT 32
30 DWL 0.100
40 GOTO 20
```

PERIOD

Set base system timer period

Format: PERIOD { time }
Group: Operating System

See also: CPU, DIAG

This command set the base system timer period, the heartbeat of most operations involving the servo loops and motion profiling. Make sure to do a CPU command to check on the system load before lowering the period, dropping the period too low may cause sluggish foreground behavior.

The recommended maximum value for the background percentage is 60% of the period, leaving at least 40% of the period for the processor to perform system tasks, such as program execution and serial/PC Bus communication. However, these recommended foreground and background percentages are generalized, and may be different based on individual system applications.

The valid range for base system timer period is 200 microseconds to 1 millisecond.

The default timer period is 500 microseconds for the ACR1200, ACR2000, ACR8000, and ACR8010 boards.

The default timer period is 750 microseconds for the ACR1500 board.

NOTE: Changing the period will affect motor tuning.

The following example sets the base system period to 200 microseconds.

Usage example:

```
PERIOD 0.0002
```

PGAIN

Set proportional gain

Format: PGAIN { axis { value } } { axis { value } } ...
Group: Servo Control
Units: volts / pulses of error

See also: IGAIN, DGAIN, FFVEL, FFACC

This command modifies the value used in the PID algorithm to control proportional gain. Issuing a PGAIN command to an axis without an argument will display the current setting for that axis. The default gain is 0.0024414 (10 volts @ 4096 pulses) for all axes.

The following example sets the X axis integral gain to 0.001 volts / pulse:

Usage example:

```
PGAIN X0.001
```

PLC

Switch to a PLC prompt

Format: PLC { number }
Group: Operating System

See also: SYS, PROG

This command switches the communication channel to the designated PLC prompt. Issuing a PLC command without an argument will either display the current PLC number or display an error (if not at a PLC level.)

The communications channel must be at a PLC level in order to run and edit PLC programs. The PLC command cannot be issued from within a program.

Usage example:

```
PLC 3
```

PLS

Programmable Limit Switch

Format: PLS index command { data }
Group: Global Objects

See also: DIM, CLEAR

This command is used with a second command to control the eight Programmable Limit Switch (PLS) objects that execute in the background. A PLS uses a source parameter to generate a table index. This table index is used to lookup an array entry which is then transferred into a destination parameter.

By pointing the source to an encoder position and the destination to the digital outputs, the PLS can sequence through a set of outputs based on a shaft position, similar to a mechanical cam operating a bank of switches.

The following is a list of valid PLS command combinations:

`PLS SRC`	Set PLS input source
`PLS DST`	Set PLS destination pointer
`PLS BASE`	Attach array to PLS
`PLS RES`	Reset or preload counter
`PLS ROTARY`	Set PLS rotary length
`PLS FLZ`	Set PLS index offset
`PLS MASK`	Set PLS output bit mask
`PLS RATIO`	Set PLS scaling ratio
`PLS ON`	Enable PLS update
`PLS OFF`	Disable PLS update

Since there are eight PLS objects, the "index" argument must be in the range of 0 to 7.

The following block diagram outlines PLS operation:

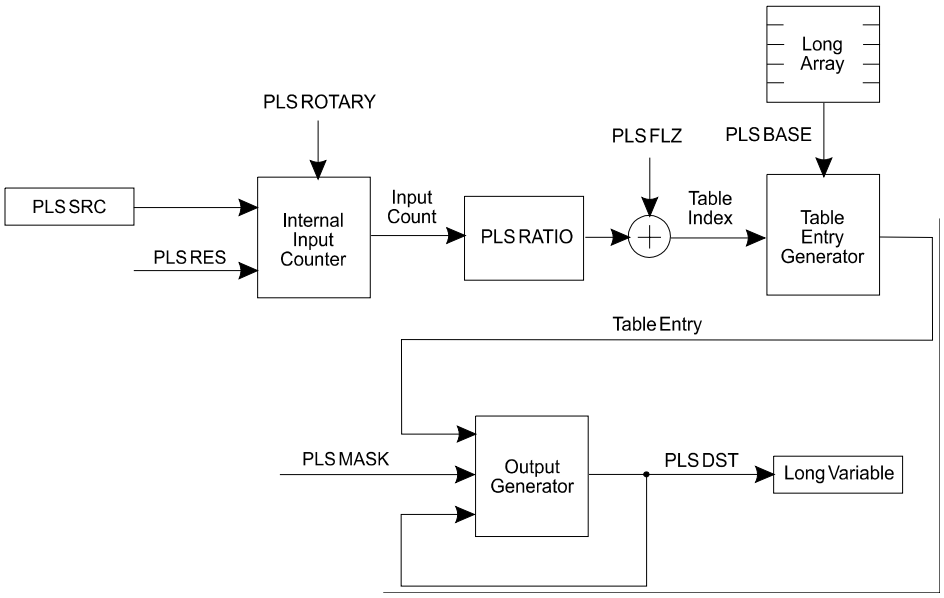


Figure 3.10 PLS block diagram

As the source changes, an internal input count is generated. If a rotary length is set with the PLS ROTARY command, the input count "wraps around" based on the rotary length. The input count can be reset or preloaded using the PLS RES command.

The internal input count is multiplied by the PLS RATIO and added to the PLS FLZ to generate a table index. The table index is used to fetch an entry from the long integer array pointed to with the PLS BASE command. If the table index is outside of the array boundaries, a zero is used instead of an array entry.

The table entry is merged with the parameter pointed to by the destination pointer. By default, the destination pointer points to P4097, the optoisolated digital outputs, but this can be changed by using the PLS DST command. The PLS can be set to modify any or all of the 32 bits in the destination parameter by using the PLS MASK command.

PLS

Programmable Limit Switch (continued)

The following example sets PLS 0 to look at ENC 0 and use the long integer array LA0 for its table of values. The mask is set to 65535 (0x0000FFFF) so that only the lower 16 bits of P4097 (OUT32 - OUT43) will be modified. The bits will sequence through a binary pattern representing the encoder position from of 0 to 1999 pulses.

These examples assume that PROG0 has enough user memory allocated inside it to accommodate a 2000 element long integer array. This memory allocation can be done using the DIM command from the SYS level.

Usage example:

```
PROG0

100 DIM LA(1)
110 DIM LA0(2000)
120 DIM LV(5)
130 LV0=0
200 LA0(LV0) = LV0
210 LV0=LV0+1
220 IF (LV0 < 2000) GOTO 200
300 PLS0 SRC ENC0
310 PLS0 BASE LA0
320 PLS0 MASK 65535
330 PLS0 ON

RUN
```

Issuing just the PLS command will display the current setting of a pls and can be used even if the pls is currently active. The example below shows the list

Usage example:

```
P00>PLS0
PLS0 BASE LA2
PLS0 FLZ 100
PLS0 MASK 121
PLS0 RATIO 2.34
PLS0 ROTARY 202
PLS0 SRC  CLOCK
PLS0 ON
```

PLS SRC

Set PLS input source

Format: PLS index SRC sourcedef
Group: Global Objects
Units: none

See also: SRC

This command specifies the source for the input of a PLS. See the SRC command for the definition of the "sourcedef" argument. The default source is NONE.

The following example sets the source of PLS 5 to encoder 3:

Usage example:

```
PLS5 SRC ENC3
```

PLS DST

Set PLS destination pointer

Format1: PLS index DST LV number
Format2: PLS index DST P number

Group: Global Objects
Units: none

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the PLS destination pointer. The two command formats allow any long integer parameter to be used as the PLS destination. The default PLS destination pointer is the address of P4097, the optoisolated digital output parameter.

The following example sets the destination of PLS 3 to P4109 (XIO-2 outputs):

Usage example:

```
PLS3 DST P4109
```

PLS BASE

Set PLS array pointer

Format: PLS index BASE LA number
Group: Global Objects
Units: none

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the PLS array pointer. The "number" argument indicates which long integer array is to be used. The array must first be allocated using the DIM command. Since there is no default for the PLS array pointer, one must be defined before the PLS ON command is issued.

The following example attaches PLS 4 to the LA2 array:

Usage example:

```
PLS4 BASE LA2
```

PLS RES

Reset or preload internal counter

Format: PLS index RES { offset }
Group: Global Objects
Units: input counts

See also: PLS, ADC, DAC, ENC, AXIS

This command resets or preloads the PLS internal input counter. If the "offset" argument is left out, the counter is set to zero. The internal counter is only used if the PLS is set to rotary operation by the PLS ROTARY command. In a linear PLS, the internal input count is always equal to the source.

The following example resets the internal counter on PLS 7 to 1000 counts:

Usage example:

```
PLS7 RES 1000
```

PLS ROTARY

Set PLS rotary length

Format: PLS index ROTARY { length }
Group: Global Objects
Units: input counts

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the PLS rotary length. Issuing a PLS ROTARY command with no argument will display the current setting. The default rotary length is 0 counts.

If the rotary length is zero, the PLS is linear and the output will be zeroed if a table index is generated that lies outside the boundaries of the PLS array. The internal input count is always equal to the current value of the source parameter when a PLS is linear.

If the rotary length is non-zero, the source parameter is used to generate an input count that "wraps-around" by the given length (modulus) before it is used to generate a table index. Note that this only affects the internal PLS input count and that it is still possible to generate table indexes outside of the array boundaries. While in rotary mode, the count can be modified with the PLS RES command.

The following example sets PLS 6 rotary length to 2000 counts:

Usage example:

```
PLS6 ROTARY 2000
```

PLS FLZ

Set PLS index offset

Format: PLS index FLZ { offset }
Group: Global Objects
Units: array entries

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the index offset. Issuing a PLS FLZ command with no argument will display the current setting. The default index offset is 0 array entries.

The following example sets the offsets PLS 3 by 10 array entries:

Usage example:

```
PLS3 FLZ 10
```

PLS MASK

Set PLS output bit mask

Format: PLS index MASK { mask }
Group: Global Objects
Units: none

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the PLS output bit mask. Issuing a PLS MASK command with no argument will display the current setting. The default mask setting is -1 (0xFFFFFFFF) allowing all bits to be transferred.

When the table entry is transferred to the location defined by the PLS DST command, the bit mask is used to determine which bits will be transferred. The bit transfer is done according to the following logic formula:

dest = (*dest* AND NOT *mask*) OR (*entry* AND *mask*)

The following example sets the mask for PLS 5 to 255, enabling the lower eight bits:

Usage example:

```
PLS5 MASK 255
```

PLS RATIO

Set PLS scaling ratio

Format: PLS index RATIO { ratio }
Group: Global Objects
Units: array entries / input count

See also: PLS, ADC, DAC, ENC, AXIS

This command sets the scaling ratio. Issuing a PLS RATIO command with no argument will display the current setting. The default index offset is 1.0 entries / count.

The following example sets the scaling ratio of PLS 2 to 0.25 entries / count:

Usage example:

```
PLS2 RATIO 0.25
```

PLS ON

Enable PLS update

Format: PLS index ON
Group: Global Objects
Units: none

See also: PLS, ADC, DAC, ENC, AXIS

This command enables PLS update.

The following example enables the update of PLS 4:

Usage example:

```
PLS4 ON
```

PLS OFF

Disable PLS update

Format: PLS index OFF
Group: Global Objects
Units: none

See also: PLS, ADC, DAC, ENC, AXIS

This command disables PLS update. The PLS output will remain in the state that it was when the PLS was turned off.

The following example disables the update of PLS 3:

Usage example:

```
PLS3 OFF
```

PPU

Set axis pulse / unit ratio

Format: PPU { axis { ratio } } { axis { ratio } } ...
Group: Feedback Control
Units: pulses / unit

See also: RES, REN

This sets the pulses per programming unit for each axis. This allows programming in inches, mm, degrees, revolutions, etc. Issuing a PPU command to an axis without an argument will display the current setting for that axis. The default is 1.0 for all axes.

The following example assumes a 1000 count encoder attached to a motor. The MULT command is the used to bring this value to 4000. The PPU command of X4000 then sets the programming units to revolutions (4000 pulses/rev) for the rest of the program. The X axis will move 200 revolutions at 20 revs/second, using 10 revs/second² ramps.

Usage example:

```
10 MULT X4
20 PPU X4000
30 ACC 10 DEC 10 STP 10
40 VEL 20
50 X200
```

Notes:

- Changing the PPU will effect the axis velocity profile as compared to its master. So the master parameters like VEL, ACC may need to be adjusted before changing the PPU of an axis.
- Don't use negative PPU value.

PRINT

Send data to a device

Format: PRINT { #device , } { USING "format string" ; } { expressionlist }
Group: Character I/O

See also: INPUT, OPEN, CLOSE

This command prints a series of expressions to a device. If no device number is given, device #0 is used. If the device is closed, or was never opened, the PRINT command is ignored. The LISTEN and LRUN commands will temporarily open device #0, allowing normal PRINT output to be monitored.

When PRINT is used in conjunction with USING, the "format string" defines the format of numeric output. In the format string, a pound sign (#) represents each digit. A plus sign (+) at the beginning of the string forces a sign for positive numbers. An optional decimal point (.) will print the number in decimal format.

Numbers are rounded as necessary. The output width will be equal to the length of the format string, right justified and padded with spaces. An exception to this rule occurs when a number is too big to fit in the defined format string. The following are examples of legitimate format strings:

"###.####"	Three leading, four trailing digits
"+###.##"	Three leading, two trailing, forced sign
"####"	Four digits total, no decimal point

The expression list is a list of expressions separated by either commas or semicolons. The comma will insert a tab character between the expressions and a semicolon will output the expressions back to back. A print statement that does not end with either a comma or a semicolon will output a carriage return / linefeed combination.

Usage example:

```
100 DIM DV(1)
110 DIM $V(1,10)
120 DV0 = 5678
130 $V0 = "ABC"
140 OPEN "COM2:19200,N,8,1" AS #1
150 PRINT #1,
160 PRINT #1, 1234; DV0, $V0;
170 PRINT #1, "DEF"
180 PRINT #1, "Outputs = "; P4097
190 PRINT #1, USING "###.####"; 1/SQRT(2)
200 PRINT #1, USING "+##.####"; COS(45)
210 CLOSE #1
```

PROG

Switch to a program prompt

Format: PROG { number }
Group: Operating System

See also: ATTACH, SYS

This command switches the communication channel to the designated program prompt. Issuing a PROG command without an argument will either display the current program number or display an error (if not at a program level.)

The prompt keeps track of your current program or system level as follows:

```
SYS>PROG3
P03>PROG1
P01>SYS
SYS>_
```

The communications channel must be at a program level in order to run and edit programs. The PROG command cannot be issued from within a program.

Usage example:

```
PROG0
```

PROGRAM / ENDP

Program without line numbers

Format: PROGRAM
Group: Program Flow

See also: ENDP

The PROGRAM command will mark the start of the program without line numbers and the ENDP command will mark the end of the program without line numbers. If ENDP command is not issued then immediate mode commands will not be executed rather they will be stored in the program space as well.

Usage example:

```
SYS
HALT ALL
NEW ALL
CLEAR
DIM PROG0(1000)
DIM DEF 10
#DEFINE     LED         BIT96
#DEFINE     myflag      BIT32
#DEFINE     TRUE        1

PROG0
#DEFINE     Counter     LV2
#DEFINE     loop        LV4

 PROGRAM
 DIM LV10
 Counter= 0
 SET myflag
 WHILE  (myflag)
      Counter= Counter+1
      FOR loop= 100 TO  500 STEP 200
            PRINT loop ;",";
            NEXT
      GOSUB SetLED
      IF  (Counter > 5)
            CLR myflag
            PRINT " Done "
            ELSE
            PRINT " Busy"
            ENDIF
      WEND
 PRINT "END OF PROGRAM"
 END

 _SetLED
 SET LED
 PRINT " led on " ; LED,
 RETURN

 ENDP
```

PROM

Dump burner image

Format: PROM index { # device }
Group: Nonvolatile

See also: ELOAD, ESAVE, ERASE, PBOOT

This command dumps a burner image of the onboard executive plus the user programs and PLC programs. By burning these images into EPROM and replacing the eproms on the boards, the card will load programs from the EPROM on powerup instead of relying on battery backup memory. User variables always reside in battery backup memory and are not affected by the program transfer.

This command is not valid for the ACR1500 board.

The "index" argument selects the image for the eproms as follows:

	ACR8000	ACR1200	ACR2000	ACR8010
0	U10	U8	U18	U13
1	U11	U9	U19	U14

The optional "device" argument allows the image to be dumped to an open channel like the PRINT command does. By using the OPEN and CLOSE commands, an EPROM burner could be connected directly to an unused serial port.

The image is dumped in "Intel MCS-86 Hex Object" format for direct download into an EPROM burner. The image can also be captured for later download. The burner must be capable of burning 4 megabit (256K x 16) devices, typically from the 27C4096 family. The device must be 175 ns or faster for normal operation and 95 ns or faster for the optional 1 wait state mode for the ACR8000. The device must be 85nsec or faster for the ACR1200/ACR2000/ACR8010 (Recommended device: ATMEL P/N AT27C4096-85JC).

The following example dumps the EPROM image for U10 on the ACR8000 daughterboard, U8 on the ACR1200, U18 on the ACR2000, or U13 on the ACR8010.

Usage example:

```
PROM 0
```

RATCH

Software Ratchet

Format: RATCH index command { data }
Group: Global Objects

See also: SRC, JOG, GEAR, CAM

This command is used along with a second command to setup software ratchets. The ratchet "index" is a number from 0 to 7. Software ratchets are sources that can ignore, negate, or buffer both positive and negative pulses.

When a ratchet is set up for buffering, pulses in the buffering direction are added to an internal count instead of causing the ratchet output to change. Pulses in the normal direction are first used to unbuffer previously buffered pulses. When there are no more pulses to unbuffer, the ratchet tracks normally.

The following is a list of valid ratchet command combinations:

`RATCH SRC`	Define ratchet source
`RATCH MODE`	Set ratchet mode

RATCH SRC

Define ratchet source

Format: RATCH index SRC sourcedef
Group: Global Objects
Units: none

See also: SRC

This command sets the input source for a ratchet. The default ratchet source is NONE. See the SRC command for the definition of the "sourcedef" argument.

The following example sets the source of ratchet 2 to encoder 7:

Usage example:

```
RATCH2 SRC ENC7
```

RATCH MODE

Set ratchet mode

Format: RATCH index MODE { mode }
Group: Global Objects
Units: none

See also: ADC, DAC, ENC, AXIS

This command sets the conversion mode for a ratchet. Issuing a mode command to a ratchet without an argument will display the current mode for that ratchet. The default ratchet mode is zero.

The following is a table of ratchet modes and their affect on incoming source pulses:

mode	positive pulses	negative pulses
0	normal	normal
1	normal	ignore
2	normal	negate
3	normal	buffer
4	ignore	normal
5	ignore	ignore
6	ignore	negate
7	ignore	buffer
8	negate	normal
9	negate	ignore
10	negate	negate
11	negate	buffer
12	buffer	normal
13	buffer	ignore
14	buffer	negate
15	buffer	buffer

Table 3.14 Ratchet Modes

The following example sets ratchet 7 to buffer negative pulses:

Usage example:

```
RATCH7 MODE 3
```

REBOOT

Reboot controller card

Format: REBOOT
Group: Operating System

See also: RUN, HALT

This command acts as if the reset button on the controller was pressed. Note that this also shuts down communications, turns off outputs, kills programs, and anything else a hardware reset does.

The following example reboots the card:

Usage example:

```
REBOOT
```

REM

Program comment

Format: REM comment
Group: Program Flow

This command causes the rest of the current line to be ignored. Execution continues at the beginning of the next line. The REM command is usually used to add comments to a program, but it may also be used to prevent the execution of a program line.

Usage example:

```
100 REM This is just a comment ...
110 REM The following line won't execute
120 REM PRINT "Old code"
130 PRINT "New code"
```

REN

Match position with encoder

Format: REN { axis } { axis } ...
Group: Feedback Control

See also: RES

This command loads the command position registers with the actual encoder position. This command is useful to learn where the axis is after the motor is turned manually with the motor power off. If the REN command is done just before motor power is applied, the controller will learn the new position and zero the D/A command signal.

Usage example:

```
10 REN X Y Z
```

RES

Reset or preload encoders

Format: RES { axis { preload } } { axis { preload } } ...
Group: Feedback Control
Units: units

See also: REN, PPU

This command zeros out the command position and the actual encoder position of the specified axes. If an optional "preload" position is specified in the command, that position is loaded into the command position and the encoder position registers.

The following example zeros the X axis command and actual position and pre-loads Y axis to 1000 units.

Usage example:

```
10 RES X Y1000
```

RESUME

Release pause mode

Format: RESUME { PROG number | ALL }
Group: Program Control

See also: RUN, HALT, TRON, TROFF, AUT, BLK, STEP, PAUSE

This command resumes the currently selected program by clearing the program's "pause control" bit. When this bit is cleared, a cycle start is issued to the attached master and the program's "pause mode" bit is cleared, resuming the program.

The RESUME PROG command will resume the corresponding program and the RESUME ALL command will resume all programs. These commands can be issued from anywhere in the system, including programs.

The following example resumes the current program:

Usage example:

```
RESUME
```

RETURN

Return from a subroutine

Format: RETURN
Group: Program Flow

See also: GOSUB, GOTO

This command causes an unconditional return from a subroutine. Program execution will continue at the command following the last GOSUB command that was executed. An error will occur if a RETURN is executed without a prior GOSUB command.

Usage example:

```
100 REM --- main program
110 PRINT "Entering the main program"
120 GOSUB 200
130 PRINT "Leaving the main program"
140 END
200 REM --- first subroutine
210 PRINT ".Entering first subroutine"
220 GOSUB 300
230 PRINT ".Leaving first subroutine"
240 RETURN
300 REM --- second subroutine
310 PRINT "..Entering second subroutine"
320 PRINT "..Leaving second subroutine"
330 RETURN
LRUN
```

Example output:

```
Entering the main program
.Entering first subroutine
..Entering second subroutine
..Leaving second subroutine
.Leaving first subroutine
Leaving the main program
```

ROTARY

Set rotary axis length

Format: ROTARY { axis { length } } { axis { length } } ...
Group: Feedback Control
Units: units

See also: NORM, RES, REN, PPU

This command sets the rotary axis length used for the shortest distance calculations. Issuing a ROTARY command without an argument will display the current setting. The default rotary length is 0.0 for all axes, disabling shortest distance moves.

If the rotary length of an axis is non-zero, a MOD function is done on absolute moves and the result is run through a shortest distance calculation. The resulting move will never be longer than half the rotary axis length. Incremental moves are not affected by the rotary axis length.

This procedure actually converts absolute moves into incremental moves that are up to plus or minus half the rotary length. Current positions are normally generated that lie outside of the rotary length boundaries. The NORM command can be used to return the current position to within the bounds of the rotary length.

The following example sets the rotary length of the A axis to 360 units:

Usage example:

```
ROTARY A360
```

ROTATE

Rotate a programmed path

Format: ROTATE rotate_angle primary {rotate_center} secondary {rotate_center}
Group: Transformation

See also: SCALE, OFFSET, FLZ

This command will cause the programmed path to be rotated about the given center point. If the rotate_center for an axis is not specified, the rotation center for that axis is equal to its current location.

The "primary" and "secondary" axes define the plane of rotation. Positive rotation is from the primary axis towards the secondary axis.

Usage example:

```
10 ROTATE 30 X1 Y2
```

ROV (Version 1.17.05 & Up)

Set rapid feedrate override

Format: ROV { rate }
Group: Velocity Profile

See also: VEL, FOV

This command sets the rapid move velocity override for the current master. The argument is a floating point scaling factor for the master's velocity profile. Issuing an ROV command without an argument will cause the current rapid feedrate override value to be displayed. The default rapid feedrate override rate is 1.0.

The rapid feedrate override takes place immediately during a rapid move (Secondary Master Flag Rapid Active is enabled). If a rapid move is in progress, the master will use its ACC or DEC settings to ramp to the new velocity.

The following example will reduce the velocities of rapid moves generated by the current master to 75% of their programmed values:

Usage example:

```
ROV 0.75
```

RUN

Run a stored program

Format1: RUN { line }
Format2: RUN { PROG number { line } | PLC number | ALL }
Group: Program Control

See also: HALT, LRUN, LISTEN

This command will run the current program and return to the command prompt. The RUN command cannot be issued from inside a program. Issuing a RUN command with the optional "line" argument will start program execution at the given line number.

The optional RUN formats can be issued from anywhere, including programs. The RUN PROG and RUN PLC commands will run the corresponding user or PLC program. The RUN ALL command will run all user and PLC programs.

Normally, when a program is run, the communication channel returns to the command prompt, allowing more commands to be entered. While at the command prompt, output from programs (including error reporting) is shut down to prevent mixing of command input and program output.

During initial program testing, it is suggested that the LRUN command be used instead of the RUN command. This will allow monitoring program output until an escape character (ASCII 27) is sent to the card or the program ends. Without the LRUN command, the program may terminate and report an error without the error actually being reported.

Usage example:

```
RUN
```

SAMP

Data sampling control

Format: SAMP { channel } command { data }
Group: Global Objects

See also: AXIS, ENC, DAC, PLS

Data sampling allows the monitoring of system parameters at the servo interrupt rate. Optionally, data may be also sampled at fixed frequency (i.e. every 25 milliseconds) or on the rising or falling edge of a bit flag.

A total of eight channels can be simultaneously filled from different parameter sources. For example, one channel can monitor actual position while another is monitoring output voltage for a given axis. The resulting information can then be transferred to an offline system for graphical plotting or tuning analysis.

The sample command is combined with other commands to prepare the system for data sampling. The following is a list of valid sample command combinations:

`SAMP SRC`	Set sample source
`SAMP BASE`	Set sample base
`SAMP CLEAR`	Clear sample channels
`SAMP TRG`	Set sample trigger

SAMP

Data sampling control (continued)

Related System Parameters:

The following is a list of system parameters related to data sampling:

P6912	Sample Array Index
P6913	Sample Trigger Index
P6914	Sample Timer Clock
P6915	Sample Timer Period

P6912 - Sample Array Index

Indicates where the next samples are going to be put in the user defined sample arrays. During sampling, if the index is greater than or equal to the size of the array, that channel is tagged as being full. If all channels are full, the index is reset and the "trigger armed" and "in progress" flags are cleared. This allows different channels to have arrays of different lengths.

P6913 - Sample Trigger Index

Set with the SAMP TRG command and is stored as a one's complement number (to allow triggering on minus zero.) A number greater than or equal to zero will trigger on an active state or a rising edge depending on the setting of the sample mode flag. A value less than zero is bitwise inverted and triggers on an inactive state or a falling edge.

P6914 - Sample Timer Clock

Indicates the number of milliseconds remaining before a sample will be taken. This value is normally zero unless the sample timer period has been set. Whenever a sample is taken, this parameter is loaded with the value in sample timer period.

P6915 - Sample Timer Period

Loaded into the sample timer clock whenever a sample is taken. This parameter is normally zero, indicating that samples should be taken at the servo interrupt rate. For edge triggered sample operation, the period indicates the number of milliseconds that will pass after an edge before a sample is taken.

SAMP

Data sampling control (continued)

Related System Flags:

The following is a list of system flags related to data sampling:

BIT104	Sample Trigger Armed
BIT105	Sample In Progress
BIT106	Sample Mode Select
BIT107	Sample Trigger Latched

BIT104 - Sample Trigger Armed

Enables monitoring of the data sample trigger which will eventually set the sample in progress flag. This flag is cleared when all of the sample channels have been filled, indicating that the sample has completed.

BIT105 - Sample In Progress

Enables an actual sample to be taken and is normally set by a sample trigger condition but can also be set manually. The flag is cleared when all of the sample channels have been filled. It is also cleared after every sample if in the edge trigger mode. This is to prevent multiple samples from being taken on the edge trigger condition.

BIT106 - Sample Mode Select

Selects either the continuous (bit clr) or edge trigger (bit set) modes of sampling. In the continuous mode, a trigger condition will set the sample in progress flag, causing a sample to be taken every servo interrupt (or sample period) until all of the sample channels have been filled. In the edge trigger mode, a trigger edge will set the sample in progress flag which is then cleared after the single sample has been taken.

BIT107 - Sample Trigger Latched

Tracks the previous state of the trigger condition for detecting trigger edges. If a trigger condition is detected and the previous trigger condition was false, an edge trigger will occur. Normally, this flag is not modified by user programs.

SAMP

Data sampling control (continued)

Code Execution Outline:

```
if  ( sample trigger armed )
      if  ( trigger condition met )
            if  ( ( level trigger ) or ( edge trigger and not trigger latched ) )
                  set sample in progress
            set trigger latched flag
      else clear trigger latched flag

if  ( sample in progress )
      if  ( sample clock > 0 )
            update sample clock
      if  ( sample clock = 0 )
            sample clock = sample period
            sample active channels
            increment sample index
            if  ( channels full )
                  clear sample armed flag
                  clear sample active flag
                  sample index = 0
            if  ( edge trigger )
                  clear sample active flag
```

SAMP

Data sampling control (continued)

Usage example:

The following example takes a 500 samples of axis 0 current position and output signal at the default servo interrupt rate of 2 kHz (250 milliseconds total sample time) :

```
PROG0
ATTACH MASTER0
ATTACH SLAVE0 AXIS0 "X"

DIM LA1
DIM LA0(500)
DIM SA1
DIM SA0(500)

SAMP CLEAR        : REM reset sample defaults

SAMP0 SRC P12290  : REM axis 0 current position
SAMP0 BASE LA0    : REM store data in LA0
SAMP1 SRC P12319  : REM axis 0 output signal
SAMP1 BASE SA0    : REM store data in SA0

SAMP TRG 516      : REM master 0 in motion flag
SET 104           : REM arm the sample trigger
X1000             : REM move axis / start sample
INH -104          : REM wait for sample done
```

SAMP SRC

Set sample source

Format: SAMP channel SRC parameter
Group: Global Objects

See also: SAMP, AXIS, ENC, DAC, PLS

This command selects a source for the given sample channel. Sample channels are numbered 0 through 7. The source 'parameter' can be either a system parameter from Appendix B or any user defined parameter.

When sampling, the channel will transfer information from the source into the array set by the SAMP BASE command. The source and base should both be of the same type since no data conversion is done during the transfer.

The following example sets SAMP 0 source to AXIS 0 actual position (P12290) and SAMP 1 source to AXIS 0 output signal (P12319) :

Usage example:

```
SAMP0 SRC P12290
SAMP1 SRC P12319
```

SAMP BASE

Set sample base

Format1: SAMP channel BASE LA index
Format2: SAMP channel BASE SA index
Group: Global Objects

See also: SAMP, AXIS, ENC, DAC, PLS

This command selects a storage array base for the given sample channel. Sample channels are numbered 0 through 7. The 'base' parameter can either a 32-bit long integer array (LA) or a 32-bit floating point array (SA).

When sampling, the channel will transfer information into this array from the source set by the SAMP SRC command. The source and base should both be of the same type since no data conversion is done during the transfer.

The following example ties sample channel 0 to the long integer array LA0 and then ties channel 1 to the 32-bit floating point array SA0:

Usage example:

```
SAMP0 BASE LA0
SAMP1 BASE SA0
```

SAMP CLEAR

Clear sample channels

Format: SAMP CLEAR
Group: Global Objects

See also: SAMP, AXIS, ENC, DAC, PLS

This command clears out all of the system parameters and flags which are related to data sampling. It also clears out any the internal pointers which may have been set with the SAMP SRC and SAMP BASE commands.

Usage example:

```
SAMP CLEAR
```

SAMP TRG

Set sample trigger

Format1: SAMP TRG + index
Format2: SAMP TRG - index
Group: Global Objects

See also: SAMP, AXIS, ENC, DAC, PLS

This command sets the trigger condition to be monitored when the sample trigger armed flag is set. A positive index will cause a trigger to occur on an active state or a rising edge, depending on the setting of the sample mode flag. A negative index will cause a trigger on an inactive state or a falling edge.

The following example will start sampling when MASTER 0 starts moving (BIT 516) :

Usage example:

```
SAMP TRG 516
```

SCALE

Scale a programmed path

Format: SCALE ratio { axis { center } } { axis { center } } ...
Group: Transformation

See also: ROTATE, OFFSET, FLZ

This command will cause the programmed path to shrink or expand about the given center point. If the"center" for an axis is not specified, the scaling center for that axis is equal to its current location.

Usage example:

```
10 SCALE 0.5 X Y
20 SCALE 2 Z1.5
```

SET

Set a bit flag

Format: SET index
Group: Logic Function

See also: CLR, INH, BIT

This command sets the specified bit flag. This flag can either be a physical output or an internal bit.

The following example pulses output 32 for 2 seconds.

Usage example:

```
10 SET 32
20 DWL 2
30 CLR 32
```

SINE

Sinusoidal move

Format: SINE { axis (target, phase, sweep, amplitude) } ...
Group: Interpolation
Units: units, degrees

See also: MOV, TRJ, PPU

This command generates a sinusoidal profile on the selected axis. When executed on two axes at the same time, the command can be used to generate circles and ellipses. The arguments for the SINE command are as follows:

target	position at the end of the sinusoid (in units)
phase	sinusoidal phase shift (in degrees)
sweep	total number of degrees in the sinusoid
amplitude	amplitude of the sinusoid (in units)

When the move is executed, an internal "current_angle" is generated that starts at 0 degrees and increases until the "sweep" value is reached. The current position of the axis is generated as follows:

current_position = center_point + amplitude * sin (phase + current_angle)

SINE

Sinusoidal move (continued)

Generating an arc::

When the X and Y axes are being used to create an arc, use the following formulas:

xsweep = theta2 - theta1
xphase = theta1 + 90
xamplitude = radius
xtarget = end position for X axis

ysweep = theta2 - theta1
yphase = theta1
yamplitude = radius
ytarget = end position for Y axis

Where:

theta1 = start angle of arc
theta2 = end angle of arc
radius = radius of the arc

xcenter = xtarget - radius * cos(theta2)
xstart = xcenter + radius * cos(theta1)

ycenter = ytarget - radius * sin(theta2)
ystart = ycenter + radius * sin(theta1)

An arc is always based on the given target point. The start point of the arc is derived from the above calculations. If the current position is not equal to the calculated start point, the arc must be proceeded with a move to (xstart, ystart) or the axes will try to jump immediately to that point.

SINE

Sinusoidal move (continued)

"Sinusoidal mode" bit:

If the "sinusoidal mode" bit is set on an axis, linear moves will be converted into SINE commands with the following parameters:

target	=	linear move target
phase	=	270 for positive moves, 90 for negative moves
sweep	=	180 degrees
amplitude	=	1 / 2 linear move distance

This is better illustrated in the following example where BIT 812 is the "sinusoidal mode" bit for the Y axis:

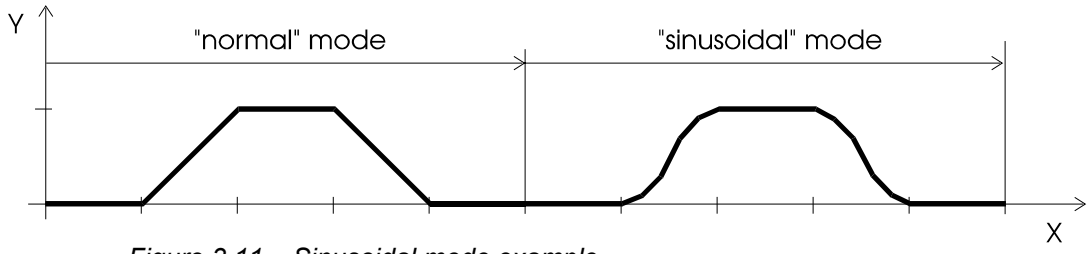


Figure 3.11 Sinusoidal mode example

```
100 VECDEF X1 Y0
110 VEL 10000
120 ACC 20000 : DEC 20000

210 CLR 812 : GOSUB 300
220 SET 812 : GOSUB 300
220 END

300 STP 0
310 X/10000 Y/0
320 X/10000 Y/10000
330 X/10000 Y/0
340 X/10000 Y/-10000
350 STP 20000
360 X/10000 Y/0
370 RETURN
```

SINE

Sinusoidal move (continued)

Circular interpolation

Usage example:

This example generates a pie-shaped path in the first quadrant.

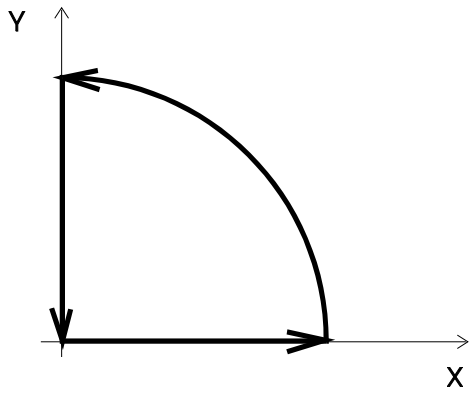


Figure 3.12 Circular interpolation example

```
10 X0 Y0
20 X10000 Y0
30 SINE X(0,90,90,10000) SINE Y(10000,0,90,10000)
40 X0 Y0
```

SINE

Sinusoidal move (continued)

Spiral interpolation

The sinusoidal interpolation can be extended to draw spiral shapes by specifying the start and end amplitude of the sine wave. Which will become the start and end radius of the spiral. The secondary master flag " Spiral Mode " should be set to activate this spiral interpolation.

```
SINE { axis (target,phase,sweep,start amplitude,end amplitude) }
```

Usage example:

```
SET 2072: REM master 0 secondary flag " spiral mode "
SINE X( 0 ,0,900,1000,5000) SINE Y( 6000,270,900,1000,5000)
```

This example generates a spiral with a start radius of 1000, end radius of 5000, sweep of 900 degrees and a target of (0,6000)

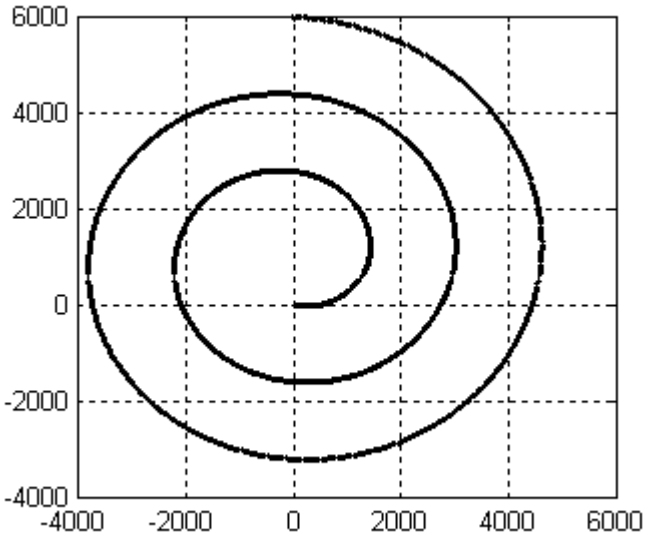


Figure 3.13 Spiral interpolation example

SPLINE (Version 1.18.04 and Up)

Cubic Spline Interpolation

Format: SPLINE command
Group: Interpolation

See Also: NURB, TMOV

This mode is not available on the ACR8000 board.

The Cubic Spline Interpolation fits a smooth curve, exactly passing through the data points specified by the user. The data points can be non-evenly spaced. This is based on the clamped Cubic Spline algorithms, thus allowing the user to specify the initial and final velocity in the algorithm

The following is a list of valid SPLINE command combinations:

`SPLINE MODE`	Enable SPLINE Interpolation Type
`SPLINE END`	End SPLINE Interpolation

The following is a typical single Spline command format for a curve in 2-D with X and Y axes.

K 3	**X5**	**Y / 2**	**VEL 5**
Knot Value of 3	Absolute target for x-axis	Incremental target for y-axis	velocity from previous knot to this knot

If the knot vectors are not included in the command, then the delta between knots is equal to the value set by TMOV command, where the first knot in Spline block is always equal to zero.

The VEL command is also optional, and ,if omitted, the previously used value is put into the next segments. The simplified Spline command would than look like.

X5	**Y / 2**
Absolute target for x-axis	Incremental target for y-axis

Note:

- The Cubic Spline algorithm uses six data point to calculate the motion trajectory. Using the INH and DWL commands in the Spline block will make the motion stop four points before the place where these commands were issued.
- To ensure good results the data points should be smoothly spaced, which means that the data can be non-uniform but does not have abrupt changes.

SPLINE

Cubic Spline Interpolation, continued

The following example uses the target spline points as shown in the following figure. The resulting Spline curve follows smooth and exactly through the spline points.

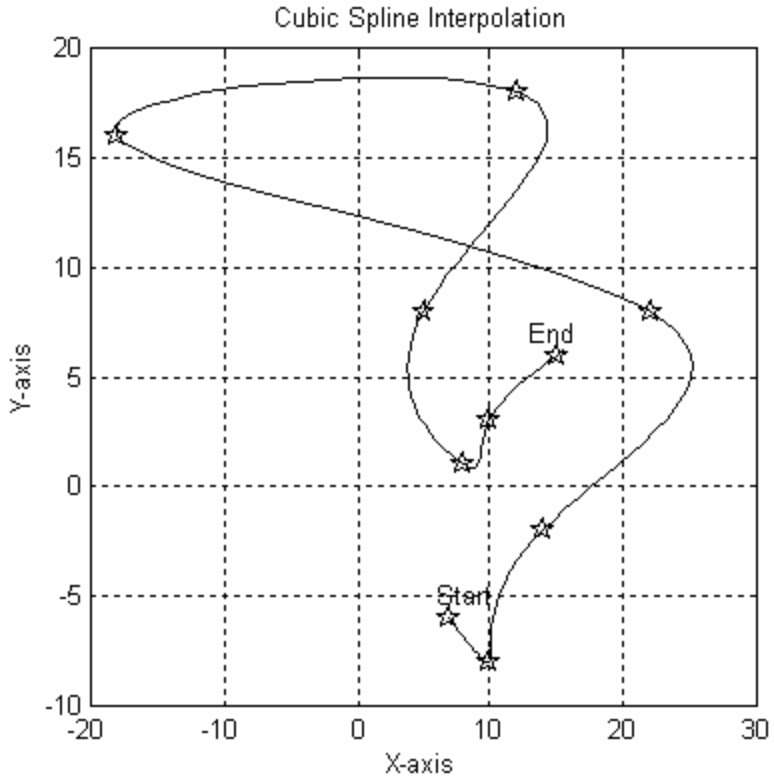


Figure 3.14 Spline interpolation example

Usage example:

```
SPLINE MODE 0
K 0 X7 Y-6

K 3 X10  Y-8
K 6 X14  Y-2
K 8 X22  Y8
K 10 X18 Y16
K 12 X12 Y12
K 14 X5 Y8
K 16 X8 Y1
K 18 X10 Y3
K20 X15 Y6
K -1
```

Time based mode is selected
If the knots are not included, than TMOV value is used as a delta between two points.
Note that first knot should be always zero.

The Spline will pass this point at exactly 10 seconds

The Spline will pass this point at exactly 20 seconds
Negative knot to indicate that Spline block has ended

SPLINE MODE (Version 1.18.04 and Up)

Enable SPLINE Mode

Format: SPLINE MODE {value} ...

This command sets the card into Spline Interpolation mode. Each Spline block should start with this command. The subsequent move commands are treated as Spline target points and Spline interpolation is used to calculate the curve path. This modes remains active till a negative knot is received, Kill Move Flag is set, or the user issues a SPLINE END command.

SPLINE Interpolation Modes

To give control over machine speed following modes are available. The user decides which one to use, depending upon the application.

MODE	SPLINE TYPE	TOV	FOV	DESCRIPTION
0	Time Interpolation	Yes	NA	• Automatic speed and acceleration control depending upon how the data points are in time. • The master parameter Spline Time Factor may be used to scale the time axis, thereby changing the speed. • Very smooth and good for high speed. • Good for making time based moves.
1	Velocity Interpolation	Yes	NS	• Linearly maps time to knots, where time between points is calculated by (Linear-Arc-length / VEL).
2	Velocity-Accel Interpolation	Yes	NS	• Linearly maps time to knots, where time between points is the maximum of (Linear-Arc-length / VEL). And $(2 \times \text{Linear-Arc-length} / \text{ACC})^{0.5}$
3	Velocity-TMOV Interpolation	Yes	NS	• Linearly maps time to knots, where time between points is the maximum of (Linear-Arc-length / VEL). And $\text{TMOV time}.^{0.5}$
4	NR Interpolation	Yes	Yes	• Newton Raphson approximation for vector velocity control.

NA: Not Applicable
NS: FOV value is applied to the next segment

The following example selects Time Interpolation Mode.

Usage example:

```
SPLINE MODE 0
```

SPLINE END (Version 1.18.04 and Up)

Ends SPLINE Interpolation Mode

Format: SPLINE END

This command is used to terminate the SPLINE interpolation mode initiated by the SPLINE MODE command.

The SPLINE ending is automatically done, if the SPLINE motion has normally come to end/stop by a negative knot. However, if stopped abnormally, like issuing incomplete or wrong data to the SPLINE profiler, then this command must be used to terminate the SPLINE mode.

Usage example:

```
SPLINE END
```

SRC

Set external timebase

Format: SRC sourcedef
Group: Velocity Profile
Units: none

See also: LIMIT, RATCH

This command specifies the timebase for coordinated motion. The source can be defined in any of the following formats:

sourcedef	description
NONE	Disconnect device from source
CLOCK	Connect to servo clock (1 pulse per period)
ENC *encoder*	Connect to encoder register
encoder	Connect to encoder register
LIMIT limiter	Connect to frequency limiter output
RATCH *ratchet*	Connect to ratchet output
parameter	Connect to user or system parameter
RES { *preload* }	Reset or preload internal source count
REN	Match internal source count to external input

During each servo interrupt, the change in source pulses is multiplied by the servo period and the resulting delta time is fed into the velocity profile mechanism. By default, the velocity profile is sourced off the CLOCK, feeding a single time unit per interrupt. Redirecting the source allows an external timebase to be used for coordinated motion.

The following example sets source of the current master to ratchet number 5:

Usage example:

```
SRC RATCH5
```

STEP

Step in block mode

Format: STEP { PROG number | ALL }
Group: Program Control

See also: AUT, BLK

This command executes the next line in block mode by setting the program's "step request" bit. Normally, this executes the next line of a program in block mode.

Step requests are ignored under the following conditions:

1. The program is not in block mode.
2. The program is in pause mode.
3. An attached master is executing a move but is not in feedhold.

If a move was in progress when the block mode was entered, the first STEP will release the feedhold on the active move and prevent the buffered move from executing by setting the master "move inhibit" bit. The second STEP will then clear the "move inhibit" bit to start the buffered move. Any further STEP commands will operate normally.

If the STEP command starts a move which is then stopped with a master "feedhold request", the next STEP does not execute the next line of the program. Instead, it releases the feedhold so that the move in progress can complete.

The STEP PROG command will step the corresponding program and the STEP ALL command will step all programs. These commands can be issued from anywhere in the system, including programs.

The following example executes the next line in block mode:

Usage example:

```
STEP
```

STP

Set stop ramp

Format: STP { rate }
Group: Velocity Profile
Units: units / second^2

See also: ACC, DEC, VEL, IVEL, FVEL, PPU

The STP command sets the master deceleration ramp to be used at the end of the next move. Issuing a STP command with no argument will display the current setting. The default stop ramp is 20000 units / second^2.

The STP command can be also be used in expressions as follows:

```
DV2 = 1 / STP
STP = DEC
```

Setting STP to zero will end the move without ramping down. This allows back-to-back moves to be merged together. The final velocity of the first move will then be the initial velocity of the second move.

Setting STP to anything other than zero will cause the move to ramp down at the end of the move to the final velocity set by the FVEL command. This value is normally zero which brings the move to a complete stop. If the final velocity is greater than zero, the move will slow down and then ramp back up on the following move.

The following example sets up accel and stop ramps of 10000 units per second^2 and then tells the system to index the X axis. This will accelerate to speed using ACC and decelerate to a complete stop using the STP value.

Usage example:

```
10 ACC 10000
20 STP 10000
30 X 10
```

SYNC (Version 1.18.01 & Up)

Synchronization of Masters

Format: SYNC {command}
Group: Velocity Profile

See also: TMOV VEL , SYNC PROG ,SYNC MDI

This group of commands is used with or without the TMOV commands to synchronize the moves of the masters. Any number and combination of masters can be synchronized together. Using the synchronized moves, instead of coordinated moves, gives the flexibility of using different motion profiles for axes connected to different masters and still be in sync.

The following is a list of valid SYNC command combinations:

`SYNC ON`	Synchronize moves of masters
`SYNC MDI`	Synchronize moves from immediate mode.
`SYNC PROG`	Synchronize moves from programs.
`SYNC OFF`	Turn off synchronization of masters

Trying to sync a master that is already in sync with another group or has no master profile, will return the respective message. Since the SYNC ON command can't be given before attaching the masters, it is preferred to use this command from the last program in the sync group. Issuing just the SYNC command with no argument will show the masters that are in sync with the program/master from which the command is issued. If the masters in the sync group need to be changed, then first use the SYNC OFF command to cancel the group and then form a new sync group by using SYNC ON command.

If any master in a sync group is given a move command that cannot be done within the time specified by TMOV, then the masters in the sync group will automatically calculate the extra time and the profile that will be needed to slow down their moves to keep in sync. Extra time demanded by each master can be seen in the Master Parameter "Delta TMOV Time".

Note

The SYNC and TMOV commands are computationally intensive. Check the CPU load, and if the background CPU time is getting close to 60%, then increase the period. For example, to run more than 4 masters on ACR8000 at the same time, it is recommended to change the period to one millisecond.

There is also a limit on how short the move can be in time. This limit could be between 5msec to 100msec, depending on the system configuration.

Synchronization of Masters, continued

Usage example:

In this example, 4 masters are used. In the group, Master0, Master1, Master2, and Master3, are synced together. Each master makes a pattern of eight moves. (For convenience sake, 1st move is at line 10, 2nd move at line 20, 3rd move at line 30, and so on for each master)

PROG0
```
ATTACH  MASTER0
ATTACH  SLAVE0 AXIS0 "X"
TMOV ON

2   ACC 1000 DEC 500 STP 0
3   VEL 300
10  X/200
20  X/200
30  X/200
40  X/200
50  X/200
60  X/200
70  X/200
75  STP1000
80  X/200
100 GOTO 2
```

PROG1
```
ATTACH  MASTER1
ATTACH  SLAVE1 AXIS1 "Y"
TMOV ON

1   IVEL 0 FVEL 0
2   ACC 1200 DEC 0 STP 1200 VEL 300
10  Y/200
15  STP 0
20  Y/200
25  STP 1200
30  Y/200
40  Y/0
45  STP 0
50  Y/200
55  STP 1200
60  Y/200
65  STP 0
70  Y/200
75  STP1200
80  Y/200
100 GOTO 1
```

PROG2
```
ATTACH  MASTER2
ATTACH  SLAVE2 AXIS2 "Z"
TMOV 1
TMOV ON

2   ACC 0 STP 0 VEL 300
10  Z/300
20  Z/300
27  ACC 1000 STP 1000 IVEL 1
30  Z/20
35  STP 0
40  Z/200
45  IVEL 0  STP 1000
50  Z/200
55  ACC 0 STP 0
60  Z/100
65  IVEL 1 ACC 1000
70  Z/200
75  IVEL 0 STP 1000
80  Z/200
100 GOTO 2
```

PROG3
```
ATTACH  MASTER3
ATTACH  SLAVE3  AXIS3  "A"
SYNC ON  MASTER0 MASTER1 MASTER2 MASTER3
TMOV ON

2   ACC 100000 DEC 100000 STP 100000 VEL 500
3   TMOV .1
10  A 20
20  A 0
30  A 20
40  A 0
50  A 20
60  A 0
70  A 20
80  A 0
100 GOTO 2
```

Synchronization of Masters, continued

Usage example:

In the following example, Master0 and Master1 each make their arcs in 3 seconds.

```
PROG0
ATTACH MASTER0
ATTACH SLAVE0 AXIS0 "X"
ATTACH SLAVE1 AXIS1 "Y"
TMOV 3
TMOV ON

10 X0 Y0
20 X10000 Y0
30 SINE X(0,90,90,10000) SINE Y(10000,0,90,10000)
40 GOTO 10


PROG1
ATTACH MASTER1
ATTACH SLAVE2 AXIS2  "Z"
ATTACH SLAVE3 AXIS3 "A"
TMOV 3
TMOV ON
SYNC ON MASTER0 MASTER1

10 Z0 A0
20 Z5000 A0
30 SINE Z(0,90,90,5000) SINE A(5000,0,90,5000)
40 GOTO 10
```

SYNC ON (Version 1.18.01 & Up)

Synchronization of Masters

Format: SYNC ON {Master #}….. {Master #}
Group: Velocity Profile

See also: TMOV VEL , SYNC PROG ,SYNC MDI

This command enables the synchronization of selected masters.

The SYNC ON command should be issued before the start of the moves. Issuing a Feed Hold Request/Cycle Start Request to one of the master in sync group will make all the masters in sync group to stop/start with their respective stop/acceleration ramps.

Usage example:

```
SYNC ON MASTER0 MASTER1
```

SYNC MDI (Version 1.18.01 & Up)

Synchronized moves from immediate mode

Format: SYNC MDI

This command is used to tell the card that the moves will be issued manually from the immediate mode and not from program i.e. PROG0 through PROG7. This command should also be used when sending binary movers. This command will set the Secondary Master Flag “Sync Manual” of all the masters in sync.

In this mode, the masters start their sync moves as soon as all the masters in sync are loaded with their respective moves.

Usage example:

```
SYNC MDI
```

SYNC PROG (Version 1.18.01 & Up)

Synchronized moves from program mode

Format: SYNC PROG

Issuing this command tells the board that the sync moves will be coming from the programs. This is the default for the sync mode. This command will clear the Secondary Master Flag “Sync Manual”.

Usage example:

```
SYNC PROG
```

Program example:

It is assumed that two masters and axes are attached and are in sync mode prior to issuing the following commands

	Sequence of Commands	Comments
PXX>	SYNC MDI	Issued once to tell that the moves will be issued from immediate mode
P00>	X/100	Loads the X-axis move
P01>	Y/200	Loads the Y-axis move, since both moves have been loaded, the two masters start the sync move.
P01>	Y/55	Load move
P00>	X 500	Load move and starts the moves
:	:	:
:	:	:
PXX>	SYNC PROG	Puts back the default sync mode in which the moves will be issued from the programs

Note:

The above two commands, SYNC PROG and SYNC MDI, are only valid when the master is in SYNC mode.

SYNC OFF (Version 1.18.01 & Up)

Asynchronization of Masters

Format: SYNC OFF {Master #} ….. {Master #}
Group: Velocity Profile

This command is used to take out any number and combination of masters from the sync mode. This command will release the master from the sync group and then the master will be able to independently execute its moves. This command can be issued any time, even if the masters are in motion.

Usage Example:

```
SYNC OFF  MASTER0  MASTER2  MASTER3
```

SYS

Return to system prompt

Format: SYS
Group: Operating System

See also: PROG

This command activates the system prompt. When a communications channel is activated, it is at the system level by default. Only limited commands can be executed from this level. The prompt at this level is as follows:

```
SYS>_
```

The communications channel must be at a program level in order to edit and run programs. This is done via the PROG command. The SYS command cannot be executed from within a program.

Usage example:

```
SYS
```

TANG (Version 1.18.06)

Tangential Axis

TANG command is useful for putting an axis to an angle to a motion path, like perpendicular, tangential or any user set angle. When an axis is put in TANG mode, it will automatically move as the motion path changes. Keeping itself to a set angle with the motion path.

TANG ON (Version 1.18.06)

Locks an axis to a Motion Path with any Angle

Format: **TANG ON {axis1 axis2 axis3}**
Group: Interpolation

The TANG ON command is used to put axis_1 tangential to the path traced by axis_2 and axis_3. Appending this command with ANG command, one can keep to any angle to the motion path of the two axes.

When the two adjacent moves have discontinuity in angle, then a move is automatically inserted to smoothly rotate the tangential axis. The user can separately set the acceleration and velocity of these inserted moves. The user can also specify minimum discontinuity between the moves for inserting the move. This is done by master parameter “TANG Turn Limit”. (Version 1.18.06 update 09).

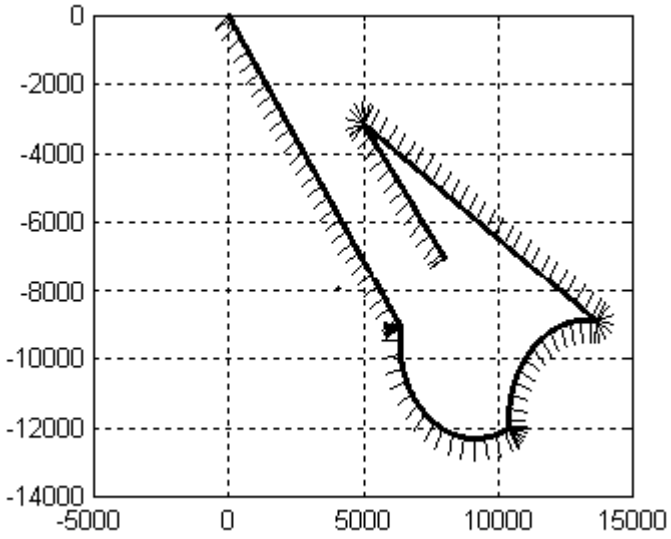


Figure 3.15 Tangential interpolation example

The following example will put z-axis perpendicular to motion of X and Y-axis. See the figure for detail.

Usage example:

```
TANG ON Z X Y ANG 90
X638 Y -907
CIRCCW X(1042.48, 916) Y(-1200.79,-950)
CIRCW X(1364.77, 1332) Y(-889.156,-1180)
X 500 Y -312.26
X800 Y -700
```

TANG OFF (Version 1.18.06)

Turn off the tangential axis

Format: **TANG OFF**
Group: Interpolation

This command will turn off the three dimensional circular interpolation mode for the master.

Usage example:

```
PROG0>TANG OFF
```

TARC (Version 1.18.06)

3-D ARC

Format: TARC { command }
Group: Interpolation

See also: MOV, SINE, SPLINE, NURB

Any three-dimensional arc between 0 to 360 degree can be traced by this interpolation mode, however it should be noted that an exact full circle can't be specified. There is no need for clockwise or counterclockwise direction, since the algorithm can automatically calculate the direction of rotation from intermediate point. In case the start, intermediate and end point are located on a straight line then a linear interpolation will be performed.

Issuing the TARC command without any argument will display ON or OFF to report if the tarc mode is active or not.

TARC ON (Version 1.18.06)

3-Dimensional Circular Interpolation Mode

Format: **TARC ON {axis axis axis}**
Group: Interpolation

This command is used to put any three of the axes attached to the master to do 3-dimensonal circular interpolation. In this mode, the 3-D Arc is defined by a start point, an intermediate point and an end point of the arc. These points can be specified as incremental or absolute position. For successive 3-D Arcs the end point of the previous arc is used as the start point of the next arc.
As required any additional number of axes can be specified to the three-dimensional interpolation axes to perform a coordinated move.

Usage example:

```
TARC OFF
X1 Y-14 Z1
TARC ON X Y Z       XYZ-axes are put to 3-D circular interpolation mode
X13 Y-6 Z5          1st Arc intermediate point
X8 Y2 Z10           1st Arc end point
X5 Y6 Z-5           2nd Arc
X10 Y2 Z-10  A2     A-axis will do linear coordinated move with XYZ-axes
X0 Y0 Z-4.5         3rd Arc intermediate point
X-10 Y-2 Z1         3rd Arc end point
X1 Y3 Z15           4th Arc
X-1 Y-2 Z1
```

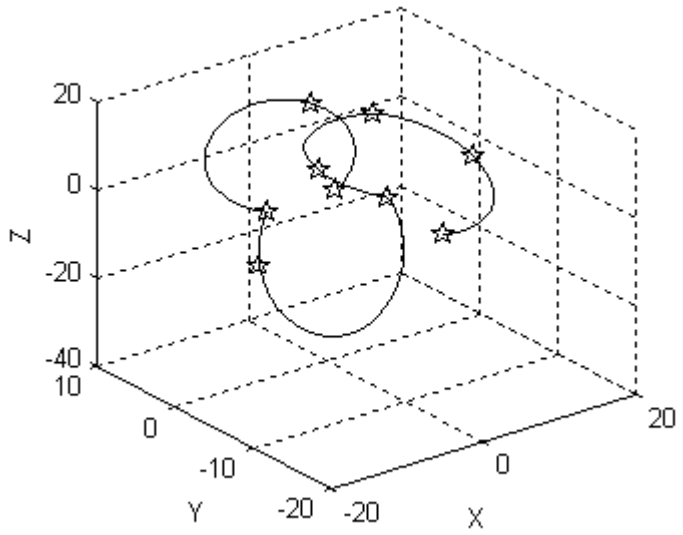


Figure 3.16 3-D Arc interpolation example

TARC OFF (Version 1.18.06)

Turn off 3-Dimensional Circular Interpolation Mode

Format: **TARC OFF**
Group: Interpolation

This command will turn off the three dimensional circular interpolation mode for the master.

Usage example:

```
TARC OFF
```

TLM

Set torque limit

Format: TLM { axis { value } } { axis { (high, low) } } ...
Group: Axis Limits
Units: volts

See also: ITB

This command sets the voltage limits monitored by the "not torque limit" flags. When the output voltage of a given axis is not being torque limited, the appropriate flag is set. Otherwise, the flag is cleared. For masters, the flag is set if none of its slaves are being torque limited.

The limits set by the TLM command cause the output of the servo loop to be clipped at the given values. See the ITB command for non-clipping torque monitoring.

Issuing the ITB command to an axis without an argument displays the current positive and negative limits for that axis. Issuing the command with a single argument sets the positive limit to "value" and the negative limit to minus "value". Issuing the command with two arguments sets the positive limit to "high" and the negative limit to "low". The default values are ±10.0 volts for all axes.

The following is a table of 'not torque limit' flags:

MASTER	BIT
0	532
1	564
2	596
3	628
4	660
5	692
6	724
7	756

AXIS	BIT
0	772
1	804
2	836
3	868
4	900
5	932
6	964
7	996

Table 3.15 'Not torque limit' flags

Usage example:

This example sets the torque limit to ±1.5 volts for both X and Y axes.

```
TLM X1.5 Y1.5
```

TMOV (Version 1.18.01 & Up)

Time Based Move

Format : TMOV {time in seconds}
Group: Velocity Profile
Units: Seconds

See also: TMOV ON , TMOV OFF, TOV, SYNC

This commands sets the time in seconds in which the moves will be completed. Issuing a TMOV command without an argument will display the current value.

This command automatically calculates the new master profile parameters to do the moves in the specified time. The new parameters, i.e. ACC, DEC, STP and VEL, are not greater than the user specified value. In other words, the user can specify the boundary of the master profile, and the TMOV commands will remain within this boundary. If the time specified is too short to complete the move, then a Secondary Master Flag bit, “Master Short Time“, is set, to indicate that the ACC, DEC, STP and VEL limits are hit. In this case, the move is carried out using the limit values.

The following is a list of valid TMOV command combinations:

`TMOV`	Set time-based move time
`TMOV ON`	Activates time-based move
`TMOV OFF`	Disables time-based move
`TMOV VEL`	Set synchronized master speed

The TMOV command only becomes active when it has been turned on by the TMOV ON command. It will remain on, unless the user turns it off by issuing a TMOV OFF command.

When using the TMOV command, use the same values for ACC, DEC and STP, if other than zero. Any combination of initial and final velocities can be used to make a move. If the user enters the initial and final velocity for the move, then these values will override the internal velocity profiler values. However, the user should not enter FVEL (final velocity) greater than (Move Distance/Move Time).

Note

FOV and ROV commands issued to the master in motion will make it slip in time for the current and the next move in the buffer. However, the subsequent moves, yet to be calculated, will adjust for this time slip. Instead, the TMOV command can be used on the fly to speedup or slow down, and the effect would be seen after the next move to be executed, which is already in the buffer.

Time Based Move, continued

The following example sets the time for the moves to complete in 0.5 seconds.

Usage example:

```
TMOV 0.5
```

The following example shows how to use the TMOV commands in a program.

Usage Example

```
PROG0
ATTACH MASTER0
ATTACH  SLAVE0 AXIS0 "X"
ATTACH SLAVE1  AXIS1 "Y"
ACC 40000 DEC 40000 STP 40000 VEL 2000

10 TMOV ON
20 TMOV .5
30 X100
40 X/400
50 TMOV 1
60 X/100
70 TMOV OFF
80 X1000
90 TMOV ON
100 X500
110 X0
120 GOTO 10
```

TMOV ON (Version 1.18.01 & Up)

Set Time Based Move

Format: TMOV ON
Group: Velocity Profile

This command will activate the time based moves. The moves will be done in the time set by the TMOV command. At the time this command is issued the current master profile parameters will be saved. This command will Set the Secondary Master Flag "Master in TMOV".

The following example activates the time based moves.

Usage example:

```
TMOV ON
```

TMOV OFF (Version 1.18.01 & Up)

Disable Time Based Move

Format: TMOV OFF
Group: Velocity Profile

This command will disable the time based moves. The moves will be done by the user specified master profile parameters. This command will Clear the Secondary Master Flags "Master in TMOV" and "Master Short Time". Halting the program will also clear both the flags.

The following example disables the time based moves.

Usage example:

```
TMOV OFF
```

TMOV VEL (Version 1.18.01 & Up)

Change the speed of a master in Sync mode

Format: TMOV VEL {value of velocity}
Group: Velocity Profile

In sync mode, this command can be used to change the speed. However, the effect will be seen after the next buffered move. Using this command instead of FOV will avoid the jerk/slip in time.

The following example sets the sync move speed to 3000.

Usage example:

```
TMOV VEL 3000
```

TOV (Version 1.18.04 & Up)

Time Over Velocity

Format : TOV {value}
Group: Velocity Profile

See also: TMOV ON , TMOV OFF, SYNC

This command is used for immediately changing the speed of the masters in motion. For example, changing the TOV from 1 to 2 will make the moves happen in half the time, or double the speed. Issuing this command will affect the velocity and acceleration as follows:

New VEL = VEL *TOV

New ACC = ACC*TOV*TOV

This change is not sudden, and the user can tune the rate of change, so that the motion profile is smooth. The rate of change for each master can be adjusted by setting the Master Parameter “TOV RATE” (default value is 2). Keep this value the same, for all the masters in sync.

Issuing this command with no argument will display the current setting.

Note:

- Issuing the TOV command for the first time attaches a special source to the master profiler. So the first time this command may be issued is when the master is not moving, otherwise a very small glitch might be seen.
- If the user decides not to use TOV command, then it should be turned off by clearing the Master Secondary Flag “Master TOV”. This will reduce unnecessary load on the CPU.
- TOV command stretches or compresses the time source. Therefore, it will be suitable for making small variations to immediately change the speed.

Usage Example:

P00>TOV
P00>1

P00> TOV 2 This will double the speed

Why TOV and not FOV

TOV is used where FOV will not work. For example in non-linear motion profiles like spline, NURBs and SYNC.

TRG

Start move on trigger

Format 1: TRG + index
Format 2: TRG - index
Group: Logic Function

See also: SET, CLR, INH

This command stores the given bit index and sets a master flag that indicates a pending TRG operation. The next move will inhibit on this condition and start immediately after the condition becomes true. This reduces the amount of time between an inhibit and the start of a move since the information is processed before the condition is met.

The following example will preload the move in line 20 and start the move as soon as output 32 becomes active:

Usage example:

```
10 TRG 32
20 X10000 Y10000
```

TRJ

Start new trajectory

Format: TRJ { axis target } { axis target } ...
Group: Interpolation
Units: units

See also: MOV, SIN, PPU

This command allows changing the trajectory of the axes on the fly. Once the TRJ command is executed, the axes will continue to go along the specified vector until one of the following conditions are met

1. The move completes normally
2. The move is aborted. (HALT (or ESCAPE in MDI))
3. Another TRJ command is received.

The following example makes the axis go along a 45 degree vector and then after 10 seconds goes at a 90 degree vector

Usage example:

```
10 TRJ X100000 Y100000
20 DWL 10
30 TRJ Y100000
```

TROFF

Turn off trace mode

Format: TROFF { PROG number | ALL }
Group: Program Control

See also: RUN, HALT, TRON, AUT, BLK, PAUSE, RESUME

This command turns off tracing for the currently selected program. When tracing is turned on, the program displays the line number of each line as it is executed. The displayed line number is enclosed in angle brackets.

The TROFF PROG command will turn off tracing for the corresponding program. The TROFF ALL command will turn off tracing for all programs. These commands can be issued from anywhere in the system, including programs.

The following example shows a program turning on and off its own tracing:

Usage example:

```
SYS>PROG0
P00>NEW
P00>10 PRINT "A";
P00>20 PRINT "B";
P00>30 TRON
P00>40 PRINT "C";
P00>50 PRINT "X";
P00>60 TROFF
P00>70 PRINT "Y";
P00>80 PRINT "Z";
P00>90 PRINT
P00>LRUN
AB<40>C<50>X<60>YZ
P00>_
```

TRON

Turn on trace mode

Format: TRON { PROG number | ALL }
Group: Program Control

See also: RUN, HALT, TROFF, AUT, BLK, PAUSE, RESUME

This command turns on tracing for the currently selected program. When tracing is turned on, the program displays the line number of each line as it is executed. The displayed line number is enclosed in angle brackets.

The TRON PROG command will turn on tracing for the corresponding program. The TRON ALL command will turn on tracing for all programs. These commands can be issued from anywhere in the system, including programs.

The following example shows a program running with and without tracing:

Usage example:

```
SYS>PROG0
P00>NEW
P00>10 DIM LV1
P00>20 LV0 = 0
P00>30 PRINT CHR$(65+LV0);
P00>40 LV0 = LV0+1
P00>50 IF (LV0 < 3) THEN GOTO 30
P00>60 PRINT
P00>TRON
P00>LRUN
<10><20><30>A<40><50><30>B<40><50><30>C<40><50><60>
P00>TROFF
P00>LRUN
ABC
P00>_
```

UNLOCK

Unlock gantry axis

Format: UNLOCK { axis } { axis } ...
Group: Setpoint Control
Units: none

See also: LOCK, BSC, CAM, GEAR, HDW, JOG

This command releases primary setpoint redirection that may have been established with the LOCK command. The actual position parameter of the axis is adjusted such that there is no change in following error when the primary setpoint switches. The default state of an axis is to follow its own setpoint.

Each axis generates a primary setpoint based on its current position, gear offset, jog offset, and cam offset. This number is normally used to tell the axis where it should be at any given time. The LOCK command tells an axis to use the primary setpoint of a different axis instead of its own. The UNLOCK command tells an axis to use its own primary setpoint once again.

The following example releases axis XB from its primary setpoint redirection:

Usage example:

```
UNLOCK XB
```

VECDEF

Define automatic vector

Format: VECDEF { axis { weight } } { axis { weight } } ...
Group: Velocity Profile
Units: none

See also: VECTOR

This command controls how the master move vector is calculated. The argument passed to an axis determines how much the axis contributes to the vector calculation. Issuing a VECDEF command to an axis without an argument will display the current setting for that axis. The default value is 1.0 for all axes.

With automatic vector calculation, the length of the master move is calculated using the following formula:

$$\text{vector distance} = \text{sqrt} \left(\sum \left(\text{delta}(n)^2 * \text{weight}(n) \right) \right)$$

where:

n	=	slave index number (from 0..7)
delta(n)	=	distance slave(n) is moving
weight(n)	=	vector contribution of slave(n)

The master will internally move from zero to the vector distance, using the current VEL, ACC, DEC, STP and FOV settings to control its velocity profile. The slaves attached to the master will start when the master starts and reach their target positions as the master finishes its move.

In many multi-axis configurations, it is not necessary (nor desirable) to have all the axes contributing to this calculation. For example, in a configuration containing three cartesian axes and a rotary axes, just the cartesian axes need to be included in the vector distance. Also, in single master / single slave setups, where the master distance is always equal to the slave distance, the default weight of 1.0 should be left alone.

For non-contributing axes, the vector weight should be set to zero. If these axes are to be moved by themselves, the automatic vector calculation must be overridden by using the VECTOR command. This may also require other initialization in preparation of the independent move.

VECDEF

Define automatic vector (continued)

Usage example:

This example makes an X,Y move with A axis interpolation.

```
10 VECDEF X1 Y1 Z1 A0
20 X10000 Y20000 A270
```

VECTOR

Set manual vector

Format: VECTOR { length }
Group: Velocity Profile
Units: units

See also: VECDEF

This command allows manual override of the default vector length calculations for moves. If VECTOR is set to zero, the vector length is calculated automatically as described in the VECDEF command. Issuing a VECTOR command without an argument will display the current setting. The default value is 0.

When a move is executed, the master controlling the move is actually making an imaginary move for a certain number of "units". The velocity profile of this move is controlled by the current VEL, ACC, DEC, STP and FOV settings.

The length of the master's move is called the "vector distance" and is either calculated automatically based on VECDEF and slave distances, or overridden manually as described here. The attached slaves start when the master starts and arrive at their target positions when the master finishes its move.

The following example makes an X,Y move with A axis interpolation. The VECTOR command is then used to move the A axis by itself as if X and Y were moving along a vector that is 1200 pulses in length:

Usage example:

```
10 VECDEF X1 Y1 Z1 A0
20 X10000 Y20000 A270
30 VECTOR 1200
40 A0
50 VECTOR 0
```

VEL

Set target velocity for a move

Format: VEL { rate }
Group: Velocity Profile
Units: units / second

See also: ACC, DEC, STP, FOV, PPU

This command sets the target velocity for subsequent indexes. Issuing a VEL command with no argument will display the current setting. The default is 10000 units / second.

This programmed velocity is over-ridden by the FOV command. The velocity changes at a rate set by the ACC, DEC and STP commands.

The following example sets the velocity to 5 inches per second. Assume that the PPU command has set 10000 pulses per inch for X axis.

Usage example:

VEL LIMIT

Sets the maximum limit of master velocity

Format: **VEL LIMIT (value)**
Group: **Profile**
See also: **VEL, FOV, ROV, MAXVEL**

This command is used to set the maximum velocity limit for a master profiler. This will protect against issuing a too high value of VEL, FOV, ROV commands etc

Example

PROG0> VEL LIMIT 10

VER (Version 1.17.05 & Up)

Display board type and firmware version

Format: VER
Group: Operating System

This command displays the board type and executive version. The board type will indicate whether the board is an ACR1200, ACR1500, ACR2000 , ACR8000 or ACR8010. The VER command cannot be issued from within a program.

Firmware Version 1.18 and above: Board type and firmware version has been added to Miscellaneous Parameters. Reference Appendix A, Miscellaneous Parameters, Board Information P7040 thru P7046.

Usage example:

```
VER
```

WHILE / WEND

Loop execution conditional

Format: WHILE (boolean) commands WEND
Group: Program Flow

WHILE loop is used to execute a set of statements if the boolean expression is true. The while loop is a prechecked loop which means that it checks the conditional expression at the beginning of the loop, not at the end. The BREAK command can be used to break out from the WHILE loop if certain other condition is met.

Usage example:

```
#DEFINE     Counter     LV0
#DEFINE     Stop        BIT32

PROGRAM
DIM LV2
Counter = 0
WHILE (Counter < 10)
      Print "Counting ",
      Print "Seconds = ", Counter
      IF (Stop)
            Print " Stop Counting"
            BREAK
      ENDIF
      Print " Dwell for 1 sec"
      DWL 1
      Counter = Counter +1
WEND

ENDP
```

CHAPTER 4
Expression Reference

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Expression Groups

Arithmetic

-	Subtraction
*	Multiplication
**	Exponent
+	Addition
/	Division
MOD	Modulus

Comparison

<	Less than
<=	Less or equal
<>	Not equal
=	Equal to
>	Greater than
>=	Greater or equal

Hyperbolic

ACOSH	Hyperbolic arc cosine
ACOTH	Hyperbolic arc cotangent
ASINH	Hyperbolic arc sine
ATANH	Hyperbolic arc tangent
COSH	Hyperbolic cosine
COTH	Hyperbolic cotangent
SINH	Hyperbolic sine
TANH	Hyperbolic tangent

Logical

<<	Left shift
>>	Right shift
AND	Logical AND
BIT	Bit flag status
NAND	Logical NAND
NOR	Logical NOR
NOT	Logical NOT
OR	Logical OR
XNOR	Logical XNOR
XOR	Logical XOR

Expression Groups

(continued)

Miscellaneous

CEIL	Smallest integer >= expression
FLOOR	Smallest integer <= expression
LN	Natural logarithm
LOG	Common logarithm
RND	Random integer
ROUND	Round to nearest integer
SQRT	Square root
TRUNC	Remove fractional part

String

ASC	ASCII Value
CHR$	Character string
INKEY$	Return a character
INSTR	String search
KBHIT	Check for waiting character
LCASE$	Convert to lower case
LEFT$	Left string
LEN	String length
MID$	Middle string
RIGHT$	Right string
SPACE$	String of spaces
STR$	Convert numeric to string
STRING$	String of characters
UCASE$	Convert to upper case
VAL	Convert string to numeric

Trigonometric

ACOS	Arc cosine
ACOT	Arc cotangent
ASIN	Arc sine
ATAN	Arc tangent
COS	Cosine
COT	Cotangent
SIN	Sine
TAN	Tangent

+

Addition

Format1: expression1 + expression2
Format2: stringexpression1 + stringexpression2
Group: Arithmetic

This operator returns the value of expression1 plus expression2.

-

Subtraction

Format: expression1 - expression2
Group: Arithmetic

This operator returns the value of expression1 minus expression2.

*

Multiplication

Format: expression1 * expression2
Group: Arithmetic

This operator returns the value of expression1 multiplied by expression2.

/

Division

Format: expression1 / expression2
Group: Arithmetic

This operator returns the value of expression1 divided by expression2.

**

Exponentiation

Format: expression1 ** expression2
Group: Arithmetic

This operator returns the value of expression1 raised to the power of expression2.

<<

Left Shift

Format: expression1 << expression2
Group: Logical

This operator returns the integer value of expression1 logically shifted to the left by expression2.

Usage example:

```
PRINT 1 << 4
PRINT 2 << 9
```

Example output:

```
16
1024
```

>>

Right shift

Format: expression1 >> expression2
Group: Logical

This operator returns the integer value of expression1 logically shifted to the right by expression2.

Usage example:

```
PRINT 256 >> 4
PRINT 4096 >> 2
```

Example output:

```
16
1024
```

<

Less Than

Format1: expression1 < expression2
Format2: stringexpression1 < stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is less than expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 < 0
PRINT 1 < 1
PRINT 1 < 2
```

Example output:

```
0
0
-1
```

=

Equal to

Format1: expression1 = expression2
Format2: stringexpression1 = stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is equal to expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 = 0
PRINT 1 = 1
PRINT 1 = 2
```

Example output:

```
0
-1
0
```

>

Greater than

Format1: expression1 > expression2
Format2: stringexpression1 > stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is greater than expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 > 0
PRINT 1 > 1
PRINT 1 > 2
```

Example output:

```
-1
0
0
```

<>

Not equal to

Format1: expression1 <> expression2
Format2: stringexpression1 <> stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is not equal to expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 <> 0
PRINT 1 <> 1
PRINT 1 <> 2
```

Example output:

```
-1
0
-1
```

<=

Less than or equal

Format1: expression1 <= expression2
Format2: stringexpression1 <= stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is less than or equal to expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 <= 0
PRINT 1 <= 1
PRINT 1 <= 2
```

Example output:

```
0
-1
-1
```

>=

Greater than or equal

Format1: expression1 >= expression2
Format2: stringexpression1 >= stringexpression2
Group: Comparison

This operator returns -1 if the value of expression1 is greater than or equal to expression2, otherwise it returns 0.

Usage example:

```
PRINT 1 >= 0
PRINT 1 >= 1
PRINT 1 >= 2
```

Example output:

```
-1
-1
0
```

ACOS

Arc cosine

Format: ACOS (expression)
Group: Trigonometric

See also: SIN, COS, TAN, COT, ASIN, ATAN, ACOT

This function returns the arc cosine of the expression.

ACOSH

Hyperbolic arc cosine

Format: ACOSH (expression)
Group: Hyperbolic

See also: SINH, COSH, TANH, COTH, ASINH, ATANH, ACOTH

This function returns the hyperbolic arc cosine of the expression.

ACOT

Arc cotangent

Format: ACOT (expression)
Group: Trigonometric

See also: SIN, COS, TAN, COT, ASIN, ACOS, ATAN

This function returns the arc cotangent of the expression.

ACOTH

Hyperbolic arc cotangent

Format: ACOTH (expression)
Group: Hyperbolic

See also: SINH, COSH, TANH, COTH, ASINH, ACOSH, ATANH

This function returns the hyperbolic arc cotangent of the expression.

AND

Logical AND

Format: expression1 AND expression2
Group: Logical

See also: NAND, OR, NOR, XOR, XNOR, NOT, BIT

This operator returns the logical AND of the two expressions. Bits in the result will be set if the corresponding expression bits are both set.

Usage example:

```
PRINT 0 AND 0
PRINT 0 AND -1
PRINT -1 AND 0
PRINT -1 AND -1
```

Example output:

```
0
0
0
-1
```

ASC

ASCII value

Format: ASC (stringexpression)
Group: String

See also: CHR$

This function returns the numeric code of the first character in the string expression. If the string is of zero length, the function returns zero.

Usage example:

```
PRINT ASC("X")
```

Example output:

```
88
```

ASIN

Arc sine

Format: ASIN (expression)
Group: Trigonometric

See also: SIN, COS, TAN, COT, ACOS, ATAN, ACOT

This function returns the arc sine of the expression.

ASINH

Hyperbolic arc sine

Format: ASINH (expression)
Group: Hyperbolic

See also: SINH, COSH, TANH, COTH, ACOSH, ATANH, ACOTH

This function returns the hyperbolic arc sine of the expression.

ATAN

Arc tangent

Format: ATAN (expression)
Group: Trigonometric

See also: SIN, COS, TAN, COT, ASIN, ACOS, ACOT

This function returns the arc tangent of the expression.

ATANH

Hyperbolic arc tangent

Format: ATANH (expression)
Group: Hyperbolic

See also: SINH, COSH, TANH, COTH, ASINH, ACOSH, ACOTH

This function returns the hyperbolic arc tangent of the expression.

BIT

Bit flag status

Format1: BIT index
Format2: BIT (expression)
Group: Logical

See also: AND, NAND, OR, NOR, XOR, XNOR, NOT

This function returns the state of a bit flag. The result is -1 if the bit is set and 0 if the bit is clear. This allows the result to be used in logical expressions.

Usage example:

```
SET 128 : PRINT BIT 128
CLR 128 : PRINT BIT 128
```

Example output:

```
-1
0
```

CEIL

Smallest integer >= expression

Format: CEIL (expression)
Group: Miscellaneous

See also: FLOOR, ROUND, TRUNC

This function returns the smallest integral value greater than or equal to the expression. The expression is rounded toward positive infinity.

Usage example:

```
PRINT CEIL(1.25)
PRINT CEIL(1.75)
PRINT CEIL(-1.25)
PRINT CEIL(-1.75)
```

Example output:

```
2
2
-1
-1
```

CHR$

Character string

Format: CHR$ (code)
Group: String

See also: ASC

This function returns a string of one character as defined by the given "code". The valid range for "code" is 0 to 255. If the value is outside that range, an error is returned.

Usage example:

```
PRINT CHR$(88)
```

Example output:

```
X
```

COS

Cosine

Format: COS(expression)
Group: Trigonometric

See also: SIN, TAN, COT, ASIN, ACOS, ATAN, ACOT

This function returns the cosine of the expression.

COSH

Hyperbolic cosine

Format: COSH (expression)
Group: Hyperbolic

See also: SINH, TANH, COTH, ASINH, ACOSH, ATANH, ACOTH

This function returns the hyperbolic cosine of the expression.

COT

Cotangent

Format: ACOT (expression)
Group: Trigonometric

See also: SIN, COS, TAN, ASIN, ACOS, ATAN, ACOT

This function returns the cotangent of the expression.

COTH

Hyperbolic cotangent

Format: COTH (expression)
Group: Hyperbolic

See also: SINH, COSH, TANH, ASINH, ACOSH, ATANH, ACOTH

This function returns the hyperbolic cotangent of the expression.

FLOOR

Largest integer <= expression

Format: FLOOR (expression)
Group: Miscellaneous

See also: CEIL, ROUND, TRUNC

This function returns the largest integral value less than or equal to the expression. The expression is rounded toward negative infinity.

Usage example:

```
PRINT FLOOR(1.25)
PRINT FLOOR(1.75)
PRINT FLOOR(-1.25)
PRINT FLOOR(-1.75)
```

Example output:

```
1
1
-2
-2
```

GETCH

Wait for a character

Format: GETCH (devicenumber)
Group: String

See also: KBHIT, INKEY$

This function returns a one character string from a device. If there is no character waiting to be read from the device, the function will wait until one becomes available.

The valid range for "devicenumber" is 0 to 3. Each program has it's own device #0 which is used as its default device. Devices #1 through #3 are board-wide system resources that can be opened and used from within any program or from any system or program prompt.

Usage example:

```
100 DIM $V(1,10)
110 OPEN "COM1:9600,N,8,1" AS #1
120 PRINT #1,
130 PRINT #1, "Press any key to continue"
140 $V0 = GETCH(1)
150 PRINT #1, "Program terminated"
160 CLOSE #1
```

INKEY$

Return a character

Format: INKEY$ (devicenumber)
Group: String

See also: KBHIT

This function returns a one character string from a device. If there is no character waiting to be read from the device, the function will return a null string.

The valid range for "devicenumber" is 0 to 3. Each program has it's own device #0 which is used as its default device. Devices #1 through #3 are board-wide system resources that can be opened and used from within any program or from any system or program prompt.

Usage example:

```
100 DIM $V(1,10)
110 OPEN "COM1:9600,N,8,1" AS #1
120 PRINT #1,
130 $V0 = UCASE$(INKEY$(1))
140 IF ($V0 = "A") PRINT #1, "Apple"
150 IF ($V0 = "B") PRINT #1, "Banana"
160 IF ($V0 = "C") PRINT #1, "Coconut"
170 IF ($V0 = "X") GOTO 200
180 GOTO 130
200 PRINT #1, "Program terminated"
210 CLOSE #1
```

INSTR

String search

Format: INSTR (stringexpression1, stringexpression2)
Group: String

This function returns the position of "stringexpression2" within "stringexpression1". If the second string can not be located within the first, the function returns zero.

If the first string is a null string, the function returns a zero. If the second string is a null string and the first string has a length greater than zero, the function returns a one.

Usage example:

```
PRINT INSTR("ABCDEFG","CDE")
```

Example output:

```
3
```

KBHIT

Check for waiting character

Format: KBHIT (devicenumber)
Group: String

See also: INKEY$

This function checks a device to see if a character is waiting to be read. If there is no character waiting to be read, the function will return a zero. Otherwise, the function will return a negative one (-1) indicating success.

The valid range for "devicenumber" is 0 to 3. Each program has it's own device #0 which is used as its default device. Devices #1 through #3 are board-wide system resources that can be opened and used from within any program or from any system or program prompt.

Usage example:

```
100 REM --- main program
110 DIM $V(1,80)
120 OPEN "COM1:9600,N,8,1" AS #1
130 PRINT #1,
140 PRINT #1, CHR$(65 + RND(26));
150 IF (KBHIT(1)) GOTO 170
160 GOTO 140
170 GOSUB 200 : REM fetch command
180 IF (UCASE$($V0) = "EXIT") GOTO 300
190 GOTO 140
200 REM --- command input
210 PRINT #1,
220 INPUT #1, "Command?", $V0
230 RETURN
300 REM --- program shutdown
310 PRINT #1, "Program terminated"
320 CLOSE #1
```

LCASE$

Convert to lower case

Format: LCASE$ (stringexpression)
Group: String

See also: UCASE$

This function returns a string with all letters in lower case. This function is useful for making string comparisons that are not case sensitive.

Usage example:

```
PRINT LCASE$("AbCdEfG")
```

Example output:

```
abcdefg
```

LEFT$

Left string

Format: LEFT$ (stringexpression, n)
Group: String

See also: RIGHT$, MID$

This function returns the leftmost "n" characters of the given string. If "n" is greater than the length of the string, the entire string is returned.

Usage example:

```
PRINT LEFT$("ABCDEFG", 3)
```

Example output:

```
ABC
```

LEN

String length

Format: LEN (stringexpression)
Group: String

This function returns the length of the given string expression.

Usage example:

```
PRINT LEN("ABCDEFG")
```

Example output:

```
7
```

LN

Natural logarithm

Format: LOG (expression)
Group: Miscellaneous

See also: LOG

This function returns the natural logarithm of the expression.

LOG

Common logarithm

Format: LOG (expression)
Group: Miscellaneous

See also: LN

This function returns the common logarithm of the expression.

MID$

Middle string

Format: MID$ (stringexpression, start, length)
Group: String

See also: LEFT$, RIGHT$

This function returns characters from the middle of the given string. If "start" is greater than the length of the string, the function returns a null string. If "length" would go beyond the end of the string, the function returns only the characters from "start" to the end of the string.

Usage example:

```
PRINT MID$("ABCDEFG", 2, 5)
```

Example output:

```
BCDEF
```

MOD

Modulus

Format: expression1 MOD expression2
Group: Arithmetic

This operator returns the modulus of the two expressions. The modulus is the remainder after dividing "expression1" by "expression2" an integral number of times. If the second expression evaluates to zero, the MOD operator returns 0.0. Otherwise, the modulus is calculated according to the following formula:

X MOD Y = X - FLOOR (X / Y) * Y

Usage example:

```
PRINT 0.7 MOD 0.3
PRINT 0.7 MOD -0.3
PRINT -0.7 MOD 0.3
PRINT -0.7 MOD -0.3
```

Example output:

```
0.1
-0.2
0.2
-0.1
```

NAND

Logical NAND

Format: expression1 NAND expression2
Group: Logical

See also: AND, OR, NOR, XOR, XNOR, NOT, BIT

This operator returns the logical NAND of the two expressions. Bits in the result will be set if the corresponding expression bits are not both set.

Usage example:

```
PRINT 0 NAND 0
PRINT 0 NAND -1
PRINT -1 NAND 0
PRINT -1 NAND -1
```

Example output:

```
-1
-1
-1
0
```

NOR

Logical NOR

Format: expression1 NOR expression2
Group: Logical

See also: AND, NAND, OR, XOR, XNOR, NOT, BIT

This operator returns the logical NOR of the two expressions. Bits in the result will be set if neither of the corresponding expression bits are set.

Usage example:

```
PRINT 0 NOR 0
PRINT 0 NOR -1
PRINT -1 NOR 0
PRINT -1 NOR -1
```

Example output:

```
-1
0
0
0
```

NOT

Bitwise complement

Format: NOT expression
Group: Logical

See also: AND, NAND, OR, NOR, XOR, XNOR, BIT

This operator returns the logical NOT of the two expressions. Bits in the result will be set if the corresponding expression bits are clear.

Usage example:

```
PRINT NOT 0
PRINT NOT -1
```

Example output:

```
-1
0
```

OR

Logical OR

Format: expression1 OR expression2
Group: Logical

See also: AND, NAND, NOR, XOR, XNOR, NOT, BIT

This operator returns the logical OR of the two expressions. Bits in the result will be set if any of the corresponding expression bits are set.

Usage example:

```
PRINT 0 OR 0
PRINT 0 OR -1
PRINT -1 OR 0
PRINT -1 OR -1
```

Example output:

```
0
1
1
1
```

RIGHT$

Right string

Format: RIGHT$ (stringexpression, length)
Group: String

See also: LEFT$, MID$

This function returns the rightmost "n" characters of the given string. If "n" is greater than the length of the string, the entire string is returned.

Usage example:

```
PRINT RIGHT$("ABCDEFG", 3)
```

Example output:

```
EFG
```

RND

Random integer

Format: RND (expression)
Group: Miscellaneous

This function returns a random integer between 0 and "expression" - 1.

Usage example:

```
100 PRINT RND(10); " ";
110 GOTO 100
LRUN
```

Example output:

```
2 5 7 3 9 0 1 3 5 7 3 8 9 7 8 3 1 0 5 4 6 8 2 ...
```

ROUND

Round to nearest integer

Format: ROUND (expression)
Group: Miscellaneous

See also: CEIL, FLOOR, TRUNC

This function returns the nearest integral value to the expression.

Usage example:

```
PRINT ROUND(1.25)
PRINT ROUND(1.75)
PRINT ROUND(-1.25)
PRINT ROUND(-1.75)
```

Example output:

```
1
2
-1
-2
```

SIN

Sine

Format: SIN (expression)
Group: Trigonometric

See also: COS, TAN, COT, ASIN, ACOS, ATAN, ACOT

This function returns the sine of the expression.

SINH

Hyperbolic sine

Format: SINH (expression)
Group: Hyperbolic

See also: COSH, TANH, COTH, ASINH, ACOSH, ATANH, ACOTH

This function returns hyperbolic sine the of the expression.

SPACE$

String of spaces

Format: SPACE$ (n)
Group: String

See also: STRING$

This function returns a string of "n" spaces.

Usage example:

```
100 PRINT "**********"
110 PRINT "*"; SPACE$(8); "*"
120 PRINT "**********"
LRUN
```

Example output:

```
**********
*        *
**********
```

SQRT

Square root

Format: SQRT (expression)
Group: Miscellaneous

This function returns the square root of the expression.

STR$

Convert numeric to string

Format: STR$ (value)
Group: String

See also: VAL

This function converts "value" to a string and returns the string.

Usage example:

```
100 DIM $V(1, 10)
110 $V0 = STR$(1.234)
120 PRINT $V0
LRUN
```

Example output:

```
1.234
```

STRING$

String of characters

Format1: STRING$ (length, code)
Format2: STRING$ (length, stringexpression)
Group: String

See also: SPACE$

This function returns a string of characters either defined by the given "code" or the first character of a string expression.

Usage example:

```
100 PRINT STRING$(5, 88)
110 PRINT STRING$(10, "*")
LRUN
```

Example output:

```
XXXXX
**********
```

TAN

Tangent

Format: TAN (expression)
Group: Trigonometric

See also: SIN, COS, COT, ASIN, ACOS, ATAN, ACOT

This function returns the tangent of the expression.

TANH

Hyperbolic tangent

Format: TANH (expression)
Group: Hyperbolic

See also: SINH, COSH, COTH, ASINH, ACOSH, ATANH, ACOTH

This function returns the of hyperbolic tangent the expression.

TRUNC

Remove fractional part

Format: TRUNC (expression)
Group: Miscellaneous

See also: CEIL, FLOOR, ROUND

This function removes any fractional part of the expression and returns an integral result. The expression is rounded toward 0.0.

Usage example:

```
PRINT TRUNC(1.25)
PRINT TRUNC(1.75)
PRINT TRUNC(-1.25)
PRINT TRUNC(-1.75)
```

Example output:

```
1
1
-1
-1
```

UCASE$

Convert to upper case

Format: UCASE$ (stringexpression)
Group: String

See also: LCASE$

This function returns a string with all letters in upper case. This function is useful for making string comparisons that are not case sensitive.

Usage example:

```
PRINT UCASE$("AbCdEfG")
```

Example output:

```
ABCDEFG
```

VAL

Convert string to numeric

Format: VAL (stringexpression)
Group: String

See also: STR$

This function converts the "stringexpression" to a numeric value and returns the value. Leading spaces and tab characters are ignored and the conversion continues until a character is reached that cannot be recognized as part of a number. If the conversion fails, the function returns a zero.

Usage example:

```
100 DIM DV(1)
110 DV0 = VAL("1.234")
120 PRINT DV0
LRUN
```

Example output:

```
1.234
```

XNOR

Logical XNOR

Format: expression1 XNOR expression2
Group: Logical

See also: AND, NAND, OR, NOR, XOR, NOT, BIT

This operator returns the logical XNOR of the two expressions. Bits in the result will be set if the corresponding expression bits are both set or both clear.

Usage example:

```
PRINT 0 XNOR 0
PRINT 0 XNOR -1
PRINT -1 XNOR 0
PRINT -1 XNOR -1
```

Example output:

```
-1
0
0
-1
```

XOR

Logical XOR

Format: expression1 XOR expression2
Group: Logical

See also: AND, NAND, OR, NOR, XNOR, NOT, BIT

This operator returns the logical XOR of the two expressions. Bits in the result will be set if only one of the corresponding expression bits is set.

Usage example:

```
PRINT 0 XOR 0
PRINT 0 XOR -1
PRINT -1 XOR 0
PRINT -1 XOR -1
```

Example output:

```
0
-1
-1
0
```

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CHAPTER 5
PLC Programming

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PLC Operation

Overview:

PLC programs are created in the same manner as user programs, but with a limited instruction set that is compiled into machine code for high-speed execution. Each PLC program can contain a maximum of 100 (200 for ACR8010) instructions. Memory for the PLC programs must be dimensioned from the system level using the DIM PLC command. On average, dimensioning 32 bytes per PLC instruction is sufficient.

PLC programs are linked into the PLC scanner, which is a list of events that are to be executed at the servo interrupt rate. During each servo interrupt, a single event from this list is executed. During the next interrupt, the next event is executed. This process is repeated after the last item in the list. In addition to PLC programs, the scanner event list also contains an input/output/clock scan and a timer/counter/latch scan.

As an example, two PLC programs running at the default 500 microsecond servo rate will be serviced every 2 milliseconds. One interrupt for the input/output/clock scan, one interrupt for the timer/counter/latch scan, and one interrupt for each of the PLC program scans. All eight PLC programs would be scanned every 5 milliseconds.

Related Parameters:

Individual PLC programs may also be instructed to scan at a rate slower than the servo interrupt rate by setting system parameters. The "tick preload" parameter controls the scan rate in milliseconds and the "tick count" indicates the number of milliseconds remaining before the PLC program is scanned.

The following table outlines parameters related to PLC operation.

PLC Number	Tick Preload	Tick Count
0	P6656	P6657
1	P6672	P6673
2	P6688	P6689
3	P6704	P6705
4	P6720	P6721
5	P6736	P6737
6	P6752	P6753
7	P6768	P6769

Table 5.1 PLC tick parameters

Related Flags:

The "PLC Running" flag is set when the RUN command is executed and cleared when the HALT command is executed. The "First PLC Scan" flag is set when a PLC program is RUN and cleared after the first PLC scan. The contact of this relay can be used for PLC reset logic as needed. The "RUN Request" and "HALT Request" flags cause the execution of RUN and HALT commands respectively.

The following table outlines bit flags related to PLC operation.

PLC Number	PLC Running	First PLC Scan	Run Request	Halt Request
0	BIT1536	BIT1537	BIT1538	BIT1539
1	BIT1568	BIT1569	BIT1570	BIT1571
2	BIT1600	BIT1601	BIT1602	BIT1603
3	BIT1632	BIT1633	BIT1634	BIT1635
4	BIT1664	BIT1665	BIT1666	BIT1667
5	BIT1696	BIT1697	BIT1698	BIT1699
6	BIT1728	BIT1729	BIT1730	BIT1731
7	BIT1760	BIT1761	BIT1762	BIT1763

Table 5.2 PLC operation flags

PLC Commands

Overview:

PLC commands control the operation of PLC programs. The PLC, PON, and POFF commands can be executed from any prompt. The RUN, HALT, LIST, and MEM commands are similar to their user program counterparts, but they act slightly different when executed from the PLC prompt.

Command List:

The following is a list of commands related to PLC programming:

PLC	Switch to PLC program
PON	Turn on PLC scanning
POFF	Turn off PLC scanning
RUN	Run PLC program
HALT	Halt PLC program
LIST	List PLC program
MEM	Show PLC memory

PLC

Switch to PLC program

Format: PLC number

Description:

This command switches the communications channel to the designated PLC prompt. The 'number' argument indicates which PLC and is in the range of 0 to 7. The command prompt keeps track of the current level as follows:

```
SYS>PROG3
P03>PLC5
PLC5>SYS
SYS>_
```

The system must be at the PLC prompt in order to run and edit PLC programs. The memory for the PLC must have been dimensioned from the system level with the DIM PLC command before PLC programs can be entered.

Usage example:

```
PLC 2
```

PON

Turn on PLC scanning

Format: PON

Description:

This command initializes the PLC scanner list to include the input/output/clock update event, any compiled PLC programs which may have been set to an idle state with the POFF command, and the timer/counter/latch update event. Running a PLC program will also cause this initialization to take place.

The input/output/clock update event is always in the PLC scanner list even if a POFF command has been issued. As the name implies, this event updates the optoisolated digital I/O, the global system clock (P6916), and the clock tick flags (BIT80 - 83) .

Note that the PON command must also be executed if the bit flags and parameters for timers, counters, or latches are to be used from normal user programs. Otherwise, the objects will not be updated by the control.

Usage example:

```
PON
```

POFF

Turn off PLC scanning

Format: POFF

Description:

This command resets the PLC scanner list to contain only the input/output/clock update event. Currently running PLC programs are put in an idle state and will be put back into the PLC scanner list when a PON command is executed.

Usage example:

```
POFF
```

RUN

Run PLC program

Format: RUN

Description:

This command will run the current PLC program and return to the command prompt. When a PLC program is run, the control first 'compiles' the PLC program source and then 'links' the result into the PLC scanner. Note that PLC programs are limited to a maximum of 100 instructions.

Compilation takes the PLC program source and generates high-speed machine code specific to the control's processor. This step requires a certain amount of memory to store the generated code. An error will be generated if there is not enough free memory available to compile the PLC program.

After the PLC program is successfully compiled, the program is linked to the PLC scanner. The 'scanner' is a list of high-speed events. During each servo interrupt, a single event from this list is executed. During the next interrupt, the next event is executed. This process is repeated after the last item in the list.

Note that running a PLC program also executes an implied PON command, activating the timer/counter/latch update event and any pending PLC programs which may have been set to an idle state with the POFF command.

Usage example:

```
RUN
```

HALT

Halt PLC program

Format: HALT

Description:

This command removes the current PLC program from the PLC scanner. If the PLC scanner is idling as the result of a POFF command, the current PLC program will not be put back into the scanner list when the PON command is executed. Halting a PLC program does not cause other PLC programs or the timer/counter/latch update event to be removed from the PLC scanner list.

Usage example:

```
HALT
```

LIST

List PLC program

Format: LIST { first } { , { last } }

Description:

This command lists the currently selected PLC program. The listings of CNT and TIM preload values reflect the current setting of the corresponding system parameters. The "first" and "last" arguments define listing ranges as follows:

LIST first	Lists a single line
LIST first, last	Lists from "first" to "last"
LIST first,	Lists from "first" to end of program
LIST ,last	Lists form start of program to "last"

Usage example:

```
LIST 100,199
```

MEM

Show PLC memory

Format: MEM

Description:

This command displays the amount of free memory remaining in the current PLC space. Running a PLC requires a certain amount of free memory to store the machine code generated during compilation. On average, a total of 32 bytes of storage are required for each PLC instruction, 8 for the source and 24 for the machine code. The memory that is displayed by this command only reflects the memory used by the source storage, even if the PLC has been compiled and is currently running.

Usage example:

```
MEM
```

PLC Instructions

Overview:

PLC instructions are combined to create PLC programs. Each instruction represents either the contact or coil of a relay on a ladder logic diagram. In the description of these instructions, a 'relay' is a bit flag, a 'contact' is an instruction that monitors the state of a bit flag, and a 'coil' is an instruction that controls the state of a bit flag.

PLC Instructions:

The following is a list of instructions related to PLC programming:

LD	Start block with NO contact
LD NOT	Start block with NC contact
AND	Add NO contact in series
AND NOT	Add NC contact in series
OR	Add NO contact in parallel
OR NOT	Add NC contact in parallel
AND LD	Connect blocks in series
OR LD	Connect blocks in parallel
OUT	Connect block to coil
TIM	Connect block to timer
CNT	Connect blocks to counter
KR	Connect blocks to latch
PBOOT	Activate PLC on powerup
END	End of PLC ladder

LD

Start block with NO contact

Formats: LD contact
LD TIM timer
LD CNT counter
LD KR latch

Description:

This instruction opens a new logic block using a normally open contact. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD 00
20 OUT 32
```

LD NOT

Start block with NC contact

Formats: LD NOT contact
LD NOT TIM timer
LD NOT CNT counter
LD NOT KR latch

Description:

This instruction opens a new logic block using a normally closed contact. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD NOT 00
20 OUT 32
```

AND

Add NO contact in series

Formats: AND contact
AND TIM timer
AND CNT counter
AND KR latch

Description:

This instruction connects a normally open contact in series with the current logic block. An error will be generated if there are no logic blocks open at that point in the PLC program. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD 00
20 AND 01
30 OUT 32
```

AND NOT

Add NC contact in series

Formats: AND NOT contact
AND NOT TIM timer
AND NOT CNT counter
AND NOT KR latch

Description:

This instruction connects a normally closed contact in series with the current logic block. An error will be generated if there are no logic blocks open at that point in the PLC program. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD 00
20 AND NOT 01
30 OUT 32
```

OR

Add NO contact in parallel

Formats: OR contact
OR TIM timer
OR CNT counter
OR KR latch

Description:

This instruction connects a normally open contact in parallel across the current logic block. An error will be generated if there are no logic blocks open at that point in the PLC program. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD 00
20 OR 01
30 OUT 32
```

OR NOT

Add NC contact in parallel

Formats: OR NOT contact
OR NOT TIM timer
OR NOT CNT counter
OR NOT KR latch

Description:

This instruction connects a normally closed contact in parallel across the current logic block. An error will be generated if there are no logic blocks open at that point in the PLC program. The 'contact' argument can be any bit flag. The other formats indicate the output contacts of global PLC timers, counters, and latches.

Usage Example:

```
10 LD 00
20 OR NOT 01
30 OUT 32
```

AND LD

Connect blocks in series

Format: AND LD

Description:

This instruction takes the two most recent logic blocks and connects them in series, creating a new logic block. An error will be generated if there are not at least two logic blocks open at that point in the PLC program.

Example Logic:

In this example, two normally open contacts from relays 00 and 01 are connected in parallel to form a block. Then a normally open contact from relay 02 and a normally closed contact from relay 03 are connected in parallel to form a second block. The two blocks are then combined in series and connected to the coil of relay 32.

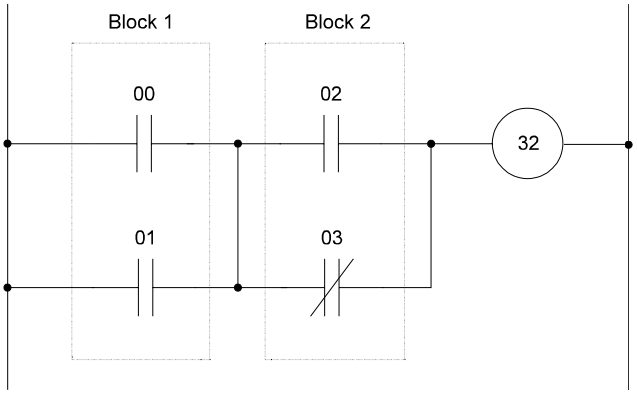

Figure 5.1 AND LD example

AND LD

Connect blocks in series, continued

Usage Example:

The following PLC code fragment implements the ladder logic shown above. Lines 100 and 110 create the first logic block. Lines 120 and 130 create the second logic block. Line 140 combines the blocks in series. Line 150 connects the block to relay 32.

```
100 LD 00
110 OR 01
120 LD 02
130 OR NOT 03
140 AND LD
150 OUT 32
```

OR LD

Connect blocks in parallel

Format: OR LD

Description:

This instruction takes the two most recent logic blocks and connects them in parallel, creating a new logic block. An error will be generated if there are not at least two logic blocks open at that point in the PLC program.

Example Logic:

In this example, two normally open contacts from relays 00 and 01 are connected in series to form a block. Then a normally open contact from relay 02 and a normally closed contact from relay 03 are connected in series to form a second block. The two blocks are then combined in parallel and connected to the coil of relay 32.

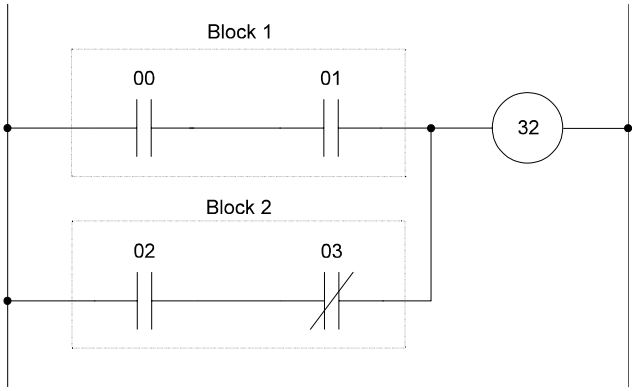

Figure 5.2 OR LD example

OR LD

Connect blocks in parallel, continued

Usage Example:

The following PLC code fragment implements the ladder logic shown above. Lines 100 and 110 create the first logic block. Lines 120 and 130 create the second logic block. Line 140 combines the blocks in parallel. Line 150 connects the block to relay 32.

```
100 LD 00
110 AND 01
120 LD 02
130 AND NOT 03
140 OR LD
150 OUT 32
```

OUT

Connect block to coil

Format: OUT coil

Description:

This instruction connects the current logic block to the coil of a relay (bit flag) and closes the logic block. The 'coil' argument can be any bit flag index. An error will be generated if there is not exactly one logic block open at that point in the PLC program. Note that this error will not be generated in the case of multiple OUT instructions even though the current block is closed after the first OUT instruction.

When a PLC program is run, the program is scanned to make sure that individual relay coils are not being controlled by multiple OUT instructions. Duplication checks are only done within a PLC program, not across multiple PLC boundaries. Relay contacts can be used any number of times.

Usage Example:

```
10 LD 00
20 OUT 32
```

TIM

Connect block to timer

Format: TIM timer { preload }

Description:

This instruction connects the current logic block to the given 'timer' coil. There are eight global PLC timers. An error will be generated if there is not exactly one logic block open at that point in the PLC program.

The optional 'preload' argument sets the timer preload parameter when the instruction is stored in the PLC. If the preload is not specified, the system parameter remains unchanged. When the PLC is listed, the TIM instruction will reflect the current timer preload setting if it has been changed by a direct parameter setting.

When a timer input is turned on, the timer count decrements once every millisecond until it reaches zero. The timer produces an output when the count is zero. When the input of a timer is turned off, the count is reset to its preload value and the output turns off. Timer counts and preloads are in milliseconds. The timer preload is retained in battery backup memory during power down, but the current timer count is not.

When a PLC program is run, the program is scanned to make sure that the individual timers are not being controlled by multiple TIM instructions. Duplication checks are only done within a PLC program, not across multiple PLC boundaries. Timer output contacts can be used any number of times.

Related Information:

The following table outlines parameters and bit flags related to PLC timers. These can be used by normal programs to control and monitor PLC timers with or without any PLC programs running. Note that if timers are to be used without PLC programs, the PON command must still be executed to enable updating of the timers.

Timer	Preload	Count	Output	Input
0	P6660	P6661	BIT1552	BIT1553
1	P6676	P6677	BIT1584	BIT1585
2	P6692	P6693	BIT1616	BIT1617
3	P6708	P6709	BIT1648	BIT1649
4	P6724	P6725	BIT1680	BIT1681
5	P6740	P6741	BIT1712	BIT1713
6	P6756	P6757	BIT1744	BIT1745
7	P6772	P6773	BIT1776	BIT1777

Table 5.3 PLC timer cross-reference

Connect block to timer (continued)

Example Logic:

In this example, a normally open contact from relay 00 and a normally closed contact from relay 01 are connected in series to form a block. This block is then connected to the input coil of timer 0 which is set for 150 milliseconds. To bring out the state of the timer, a normally open contact from the timer is connected to the coil of relay 32.

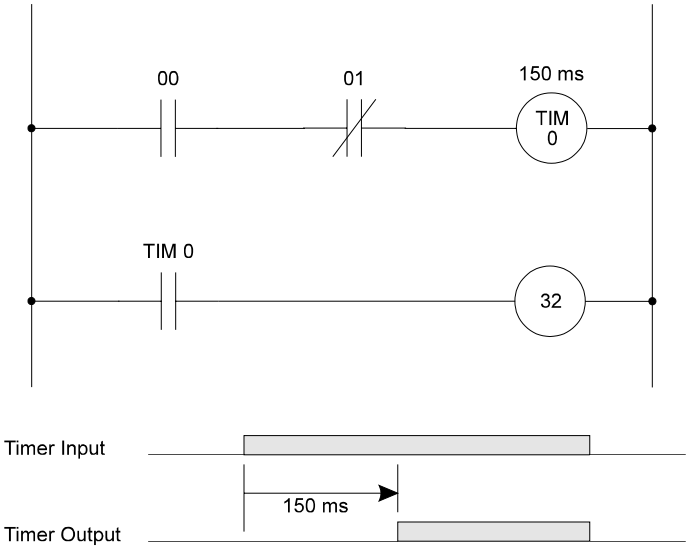

Figure 5.3 PLC timer example

TIM

Connect block to timer (continued)

Usage Example:

The following PLC code fragment implements the ladder logic shown above. Lines 100 and 110 create a new logic block. Line 120 connects the block to timer 0 and sets the timer to 150 milliseconds. Lines 130 and 140 connect the timer output to relay 32.

```
100 LD 00
110 AND NOT 01
120 TIM 0 150
130 LD TIM 0
140 OUT 32
```

CNT

Connect blocks to counter

Format: CNT counter { preload }

Description:

This instruction takes two logic blocks and connects them to the given 'counter'. The first block is connected to the 'clock' coil and the second block is connected to the 'reset' coil. There are eight global PLC counters. An error will be generated if there are not exactly two logic blocks open at that point in the PLC program.

The optional 'preload' argument sets the counter preload parameter when the instruction is stored in the PLC. If the preload is not specified, the system parameter remains unchanged. When the PLC is listed, the CNT instruction will reflect the current counter preload setting if it has been changed by a direct parameter setting.

A counter decrements once on every rising edge of its clock input until it reaches zero. The counter produces an output when the count is zero. When the reset input of a counter is turned on, the counter is reset to its preload value and the output turns off. Clock inputs are ignored while the reset input is on. Both the current count and preload are retained in battery backup memory during power down.

When a PLC program is run, the program is scanned to make sure that the individual counters are not being controlled by multiple CNT instructions. Duplication checks are only done within a PLC program, not across multiple PLC boundaries. Counter output contacts can be used any number of times.

Related Information:

The following table outlines parameters and bit flags related to PLC counters. These can be used by normal programs to control and monitor counters with or without any PLC programs running. Note that if counters are to be used without PLC programs, the PON command must still be executed to enable updating of the counters.

Counter	Preload	Count	Output	Clock	Reset
0	P6662	P6663	BIT1556	BIT1557	BIT1558
1	P6678	P6679	BIT1588	BIT1589	BIT1590
2	P6694	P6695	BIT1620	BIT1621	BIT1622
3	P6710	P6711	BIT1652	BIT1653	BIT1654
4	P6726	P6727	BIT1684	BIT1685	BIT1686
5	P6742	P6743	BIT1716	BIT1717	BIT1718
6	P6758	P6759	BIT1748	BIT1749	BIT1750
7	P6774	P6775	BIT1780	BIT1781	BIT1782

Table 5.4 PLC counter cross-reference

CNT

Connect blocks to counter (continued)

Example Logic:

In this example, a normally open contact from relay 00 and a normally closed contact from relay 01 are connected in series to form a block. Then a normally open contact from relay 02 forms a second block. These blocks are then connected to the clock and reset coils of counter 1 which is set to 5 counts. To bring out the state of the counter, a normally open contact from the counter is connected to the coil of relay 32.

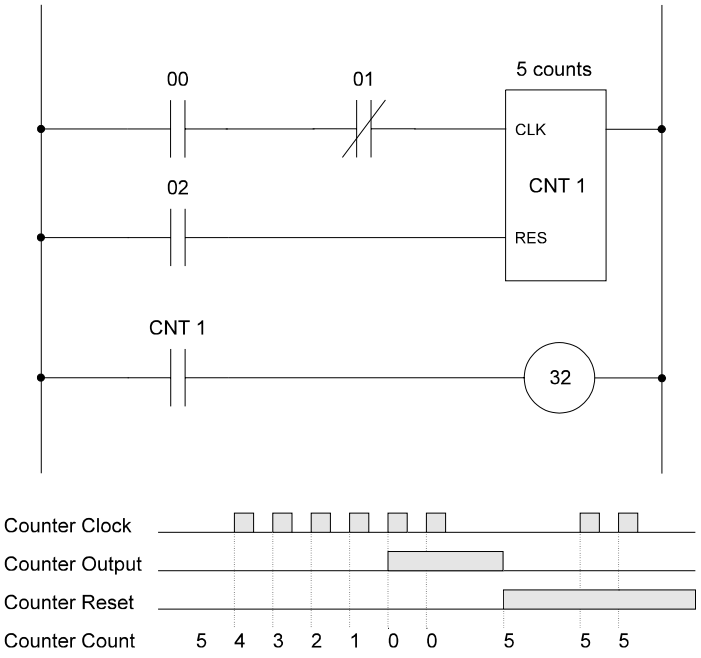

Figure 5.4 PLC counter example

CNT

Connect blocks to counter (continued)

Usage Example:

The following PLC code fragment implements the ladder logic shown above. Lines 100 and 110 create the first block. Line 120 creates the second block. Line 130 connects the two blocks to counter 1 and sets the count to 5. Lines 140 and 150 connect the counter output to relay 32.

```
100 LD 00
110 AND NOT 01
120 LD 02
130 CNT 1 5
140 LD CNT 1
150 OUT 32
```

KR

Connect blocks to latch

Format: KR latch

Description:

This instruction takes two logic blocks and connects them to the given 'latch'. The first block is connected to the 'set' coil and the second block is connected to the 'reset' coil. There are eight global PLC latches. An error will be generated if there are not exactly two logic blocks open at that point in the PLC program.

A latch output turns on when its set input is turned on. The latch output will remain on even after the set input goes away. When the reset input of a latch is turned on, the latch output will turn off. The set input is ignored when the reset input is turned on. The output state of a latch is retained in battery backup memory during power down.

When a PLC program is run, the program is scanned to make sure that the individual latches are not being controlled by multiple KR instructions. Duplication checks are only done within a PLC program, not across multiple PLC boundaries. Latch output contacts can be used any number of times.

Related Information:

The following table outlines the bit flags related to PLC latches. These can be used by normal programs to control and monitor PLC latches with or without any PLC programs running. Note that if latches are to be used without PLC programs, the PON command must still be executed to enable updating of the latches.

Latch	Output	Set	Reset
0	BIT1564	BIT1565	BIT1566
1	BIT1596	BIT1597	BIT1598
2	BIT1628	BIT1629	BIT1630
3	BIT1660	BIT1661	BIT1662
4	BIT1692	BIT1693	BIT1694
5	BIT1724	BIT1725	BIT1726
6	BIT1756	BIT1757	BIT1758
7	BIT1788	BIT1789	BIT1790

Table 5.5 PLC latch cross-reference

Connect blocks to latch (continued)

Example Logic:

In this example, two normally open contacts from relays 00 and 01 are connected in series to form a block. Then two normally open contacts from relays 02 and 03 are connected in series to form a second block. These blocks are then connected to the set and reset coils of latch 1. To bring out the state of the latch, a normally open contact from the latch is connected to the coil of relay 32.

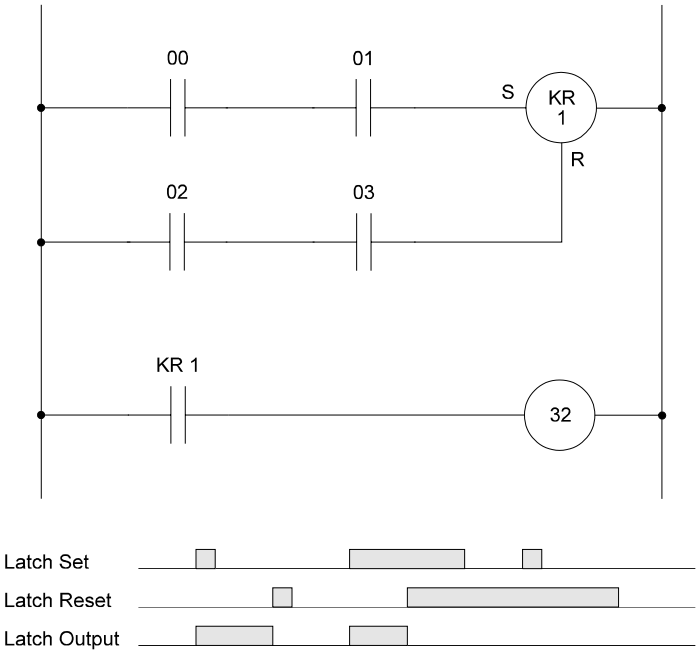

Figure 5.5 PLC latch example

KR

Connect blocks to latch (continued)

Usage Example:

The following PLC code fragment implements the ladder logic shown above. Lines 100 and 110 create the first block. Lines 120 and 130 create the second block. Line 140 connects the blocks to latch 1. Lines 150 and 160 connect the latch output to relay 32.

```
100 LD 00
110 AND 01
120 LD 02
130 AND 03
140 KR 1
150 LD KR 1
160 OUT 32
```

PBOOT

Activate PLC on powerup

Format: PBOOT

Description:

If used, this instruction should be the first instruction of a PLC program. On powerup, the system checks the beginning of all PLC programs for a PBOOT instruction. If it finds one, the run request flag for that PLC is set.

Usage Example:

```
10 PBOOT
20 LD 00
30 OUT 32
```

END

End of PLC ladder

Format: END

Description:

This instruction indicates the end of the current PLC ladder. Although typically the last instruction in a PLC program, it may also be inserted in the middle to "cut off" the rest of the ladder. If there is no END instruction in a PLC program, the PLC will execute up to and including the last instruction.

Usage Example:

```
10 LD 00
20 OUT 32
30 END
40 LD 01
50 OUT 33
```

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